



The Blast Furnace and Steel Plant

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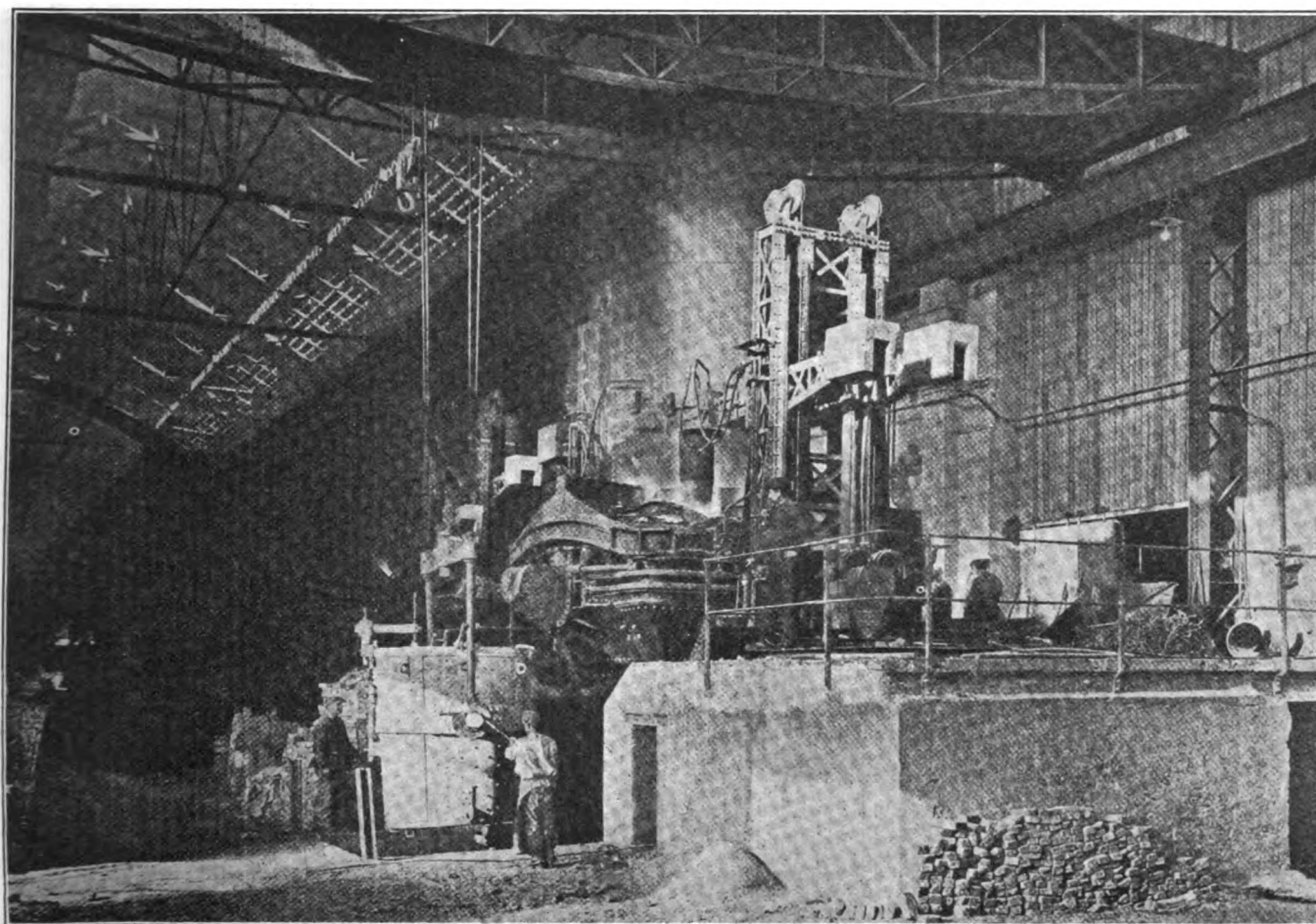
The Blast Furnace *and* Steel Plant

The Paul Girod Electric Steel Furnace

**Electric Furnace Built in France Has Points of Interest.
Furnace Works Almost Entirely by Resistance When Starting
on Cold Charge—Methods of Recarbonizing and Deoxidizing.**

Electric steel production has been given such an impetus in this country during the last few months that it is interesting to note the progress in electric furnace construction and operation which is being

which is supplied through the carbon electrodes suspended over the furnace body, forms an arc over the surface of the metallic bath, goes through this latter, and leaves by the hearth. The furnace is built by the



Showing a large Paul Girod furnace constructed in France—The manner of installation facilitating efficient operation is of interest.

made by our allies. Sometime ago a detailed description of the Paul Girod furnace appeared in London "Engineering," from which the following data and illustration has been taken:

"The Paul Girod electric steel furnace is an arc furnace having a conducting hearth. The current,

Compagnie des Forges et Aciéries Electriques Paul Girod, Ugine, Savoie, France.

"Conductivity in the hearth is obtained by embedding bottom electrodes in the refractory lining, made of dolomite or magnesite; the bottom electrodes are of mild steel, they run through the furnace bottom

plate and slightly project inside the furnace above the refractory lining. The bottom electrodes, which are six in number for a two-ton furnace and 16 for a 20-ton furnace, are placed at an equal distance apart, round the periphery of the hearth. The upper part of the bottom electrodes in contact with the bath melt over a height of from 5 to 6 cm (1.9 to 2.3 inches); the lower part, outside the furnace plating, has a cavity in which there is provided water circulation, the effect of which is to decrease the length subject to melting and to tend to increase the life of the refractory hearth. The connection for the outgoing current is made below the bottom electrodes.

"The furnace is covered by a silica brick arch in which are cut the openings for the carbon electrodes, a small clearance being provided between these and the sides of the openings. The charging door is at the back of the arch. The metal bath is 20 to 37 cm (7.8 to 11.8 inches) in thickness. The dimensions and number of the upper electrodes vary with the size of the furnace. The furnaces of from two to three tons have one electrode; those of larger size have a suitable number, divided over the surface of the bath and forming as many sources of heat, with the object of equalizing the temperature throughout the whole of the furnace. The 20-ton furnaces at the Ugine steel works have four carbon electrodes. Whatever be the number of carbon electrodes, they are connected in multiple, and the furnace is supplied with direct or single-phase current. It is possible, and also advantageous in certain circumstances, to make three-phase connections in furnaces having three, or also an even number of electrodes, in which case the conducting hearth is also resorted to, the furnace working equally well as with the other arrangement. The principle of having a conducting hearth, which compels the current to flow through the whole of the charge, is particularly advantageous from several points of view. When starting with a cold charge the furnace works almost entirely by resistance, and heating is carried out regularly over the whole depth of the charge. This working by Joule effect is, of course, only of small importance after melting has taken place; it is not negligible, nevertheless, and no doubt it is one of the causes by which the method comprising a conducting hearth also secures the equalizing of the temperature in the bath. The current circuit from the carbon electrodes to the hearth, through the bath, forms one arc and makes it easy to control the working of the furnace. Each electrode has its own regulating device, which operates independently of the working of the other electrodes.

"From the metallurgical point of view the operation for the manufacture of steel is always carried out in one and the same way. A charge of scrap and steel turnings is introduced, with material for a preliminary slag, consisting of lime and iron ore; the mixture of

this oxidizing slag is such that when melting is complete the metal bath must be completely refined—the composition being: carbon, 0.1 per cent; silicon, 0.05 per cent; manganese, 0.1 per cent, as shown by test specimens. If necessary, the action of this oxidizing slag is extended, or it is strengthened by the addition of iron ore until the required degree of refining is attained.

"The preliminary slag is then poured out and is replaced by an extra-basic slag obtained by the addition of pure lime; this calcareous slag, in the presence of the refined and oxidized bath, insures active dephosphorizing. When the calcareous slag has been very carefully removed the bath is ready for deoxidizing and recarbonizing, and the giving of the required character to the metal; these latter operations are carried out in the presence of a neutral slag composed of lime and silica. Recarbonizing is effected with charcoal, or with powdered or agglomerated graphite; deoxidizing is carried out by the addition of energetic reducing agents such as silicon, manganese, aluminum, in the shape of ferro-alloys, and carbon. These reducing agents act either in the bath itself or in the slag, where they reduce the oxide of iron which the latter tends to absorb. Towards the end of the deoxidizing period, thanks to the sufficiently high temperature, to the basicity of the slag and its low content in iron oxide, an intensive desulphurizing action takes place. The percentage of carbon is made up by the addition of coal or pig iron, and the operation is completed by the addition of silicon, manganese, nickel, chromium, tungsten, etc., varying with the grade of steel required.

"According to the purpose to which the steel is destined, the operation is carried out so as to arrive at a greater or lesser degree of refining; thus the percentages of sulphur and phosphorus, which may be 0.020 per cent in ordinary steels, are lowered to 0.005 per cent in special and tool steels."

It is interesting to note in connection with this description the remarks made by Walter C. Kennedy before the A. I. S. E. E. last September: "The use of the electric furnace in the steel industry has increased to such an extent that its permanency is now assured. At first, it was used for high carbon and alloy steels, but it is now extending to the manufacture of lower carbon steels comparable with the grades at present produced in the open hearth furnace. The electric furnace, like the electric motor, has advanced directly with the comparatively recent and rapid growth of the modern power distribution systems. As nearly all power systems are supplying 60-cycle, three-phase current, it is entirely pertinent to consider the growth of the use and size of the electric furnace along this line. The majority of electric arc furnaces for the manufacture of steel or other ferrous alloys run from five or six tons' capacity down."

Theory of Heat Conduction and Transfer

The Importance of Heat Condition and Radiation as Effecting Metallurgical Processes — Tables and Formula Presented for the Calculation of Various Cases of Heat Transfer.

By A. D. WILLIAMS.

Heat conductivity is analogous to electrical conductivity; that is, it varies directly with the length and inversely as the cross-section of the conductor. That is the amount of heat transmitted between two parallel planes within a body will depend directly upon the heat resistivity of the body per unit of area and length and the temperature difference between the two planes. The heat resistivity is the reciprocal of the heat conductivity k which is expressed in gram calories per second per square centimeter, per degree centigrade per centimeter. It is comparatively easy to determine the resistance to heat flow within a body but in practice we have to deal with the inflow of heat to that body from a gas, a solid or a liquid at a surface and an outflow of heat from its surface. This involves an emissivity factor which varies with the material and with surface conditions; this factor is also involved in radiation problems. When the inflow or outflow of heat at a surface occurs between a solid and a liquid, or a solid and a gas, the effects of convection are involved as well as the position of the surface. Convection depends upon the rate of flow, the temperature difference and emissivity. Radiation depends upon emissivity and the difference of the fourth powers of the absolute temperatures.

Temperature penetration is analogous to heat flow and is governed by the specific heat, density and conductance; these factors being combined in one called the diffusivity of the body. The time required for any plane in a body to reach an assumed percentage of the surface temperature varies as the square of the distance from the surface to that plane. These problems as involved in metallurgical work fall under the general case of the solid with two parallel bounding planes—the slab, and come under what may be called the "theory of the fireproof" wall.

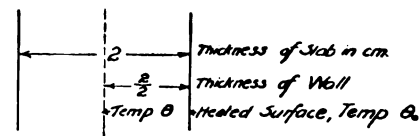
Case A—In which one face of the wall is raised to and maintained at an assumed temperature while the opposite face of the wall is protected so that it suffers no loss of heat.

Case B—Is the same as case A, except that the rise in temperature of the exposed face is gradual.

Case C—The front face of the wall is suddenly raised to an assumed temperature and the rear face loses heat by radiation and convection.

Case A is the one under which fall regenerator checkerwork and stove checkerwork, where both faces of the wall are heated. **Case C** covers recuperators and furnace walls. The exact method of dealing with

case C is extremely difficult, but it is possible to reach a solution accurate enough for practical purposes, though the formula is rather complicated. A rough, very rough approximation may be made by assuming the outside or cooling face of the wall will not exceed a certain temperature, or that the temperature drop



$$\theta = \theta_0 \left\{ 1 - \frac{4}{\pi} e^{-\frac{h^2 \pi^2 t}{2^2}} + \frac{4}{3\pi} e^{-\frac{9h^2 \pi^2 t}{2^2}} - \frac{4}{5\pi} e^{-\frac{25h^2 \pi^2 t}{2^2}} + \dots \right\}$$

Let Temp $\theta = y = A$ fraction at θ_0

Let $x = 0.4343 \frac{h^2 \pi^2 t}{2^2}$

$$y = 1 - \frac{4}{\pi} \left\{ 10^{-x} - \frac{1}{3} 10^{-9x} + \frac{1}{5} 10^{-25x} - \frac{1}{7} 10^{-49x} + \dots \right\}$$

$h^2 = \left(\frac{k}{cp} \right)$ - Diffusivity

t - time in seconds

p - density

c - specific heat

k - conductivity

Case A.

$$\theta = \frac{\theta_0}{\pi} \int_0^{\frac{b+x}{2h\sqrt{t}}} e^{-\beta^2} d\beta + 2\theta_0 e^{(b+x)^2 \frac{h^2 \pi^2 t}{2^2}} \left(1 - \frac{2}{\pi} \int_0^{\frac{b+x+2h^2 \pi^2 t}{2h\sqrt{t}}} e^{-\beta^2} d\beta \right)$$

Case C.

through the wall, after stable conditions are reached, will have a certain value; the problem then falls under the formula for case A.

Table of the Values of the Function y for Values of x .

x	y	x	y	x	y	x	y
0.01	0.000	0.11	0.0546	0.25	0.2864	0.80	0.7982
0.02	0.0000	0.115	0.0619	0.26	0.3022	0.85	0.8202
0.03	0.0000	0.12	0.0692	0.27	0.3178	0.90	0.8397
0.035	0.0001	0.125	0.0768	0.28	0.3331	1.00	0.8727
0.04	0.0005	0.13	0.0848	0.29	0.3480	1.10	0.8989
0.045	0.0010	0.135	0.0927	0.30	0.3727	1.25	0.9284
0.05	0.0021	0.14	0.1009	0.32	0.3912	1.50	0.9597
0.055	0.0037	0.145	0.1092	0.34	0.4184	1.75	0.9774
0.06	0.0055	0.15	0.1176	0.36	0.4444	2.00	0.9873
0.065	0.0081	0.16	0.1345	0.38	0.4693	2.25	0.9928
0.07	0.0113	0.17	0.1517	0.40	0.4931	2.50	0.9960
0.075	0.0150	0.18	0.1690	0.45	0.5482	2.75	0.9977
0.08	0.0194	0.19	0.1862	0.50	0.5974	3.00	0.9987
0.085	0.0241	0.20	0.2033	0.55	0.6412	3.25	0.9993
0.09	0.0294	0.21	0.2204	0.60	0.6802	3.50	0.9996
0.095	0.0351	0.22	0.2372	0.65	0.7150	3.75	0.9998
0.10	0.0412	0.23	0.2539	0.70	0.7460	4.00	0.9999
0.105	0.0478	0.24	0.2702	0.75	0.7736		

NOTE—This table and the formula for case "A" and "C" from "Mathematical Theory of Heat Conduction," by Ingersoll and Zobel.

The formula covering case A can be solved by the use of the tabular values of x working t as a variable, then plotting the curves. The diffusion curve given in the January issue of THE BLAST FURNACE AND STEEL PLANT was computed in this manner and the work only required two letter sheets of paper, the largest portion of the time being required in reading and recording the slide rule values of t .

One of the main difficulties arises from the fact that the physical characteristics of refractories and insulators of heat have not been accurately determined at high temperatures. In work of this kind the illogical relationship of the English units complicates computations and requires more than five times the amount of labor that is necessary in working with metric units, and it is probably due to this fact that very little work has been done in the non-metric using countries. At the best the subject is none too simple.

In considering the outer walls of furnaces and stoves it is necessary to limit the temperature of the inner surface below that of the fusing or breaking down of the brick. The outside temperature must be kept as low as consistent with the preceding requirement in order to reduce the amount of heat wasted to a minimum. In furnaces which have come under the writer's observation the outer wall surface has rarely been hotter than 200 deg. above the atmosphere, while the temperature drop through the wall has varied from 3 to 40 deg. per cm.

The value of the emissivity constant E may be taken for small temperature ranges at about 0.0003 gramme calories per second per square centimeter per degree centigrade above the temperature of the surroundings, for average surface such as a wall. Strong convection currents or high temperature differences may increase this figure considerably, while the position of the surface or the protective influence of surroundings may decrease this constant. In a paper by Irving Langmuir before the American Electro-chemical Society in 1913, he gave the results of experiments covering the convection from horizontal and vertical surfaces to still air at 27 deg. as follows:

Convection in Gramme Calories per Second per Square Centimeter to Still Air at 27 deg.

Temperature of surface..	100°	200°	300°	400°	500°
Downward from horizontal surface.....	0.002	0.014	0.024	0.035	0.047
From perpendicular surface	0.005	0.029	0.050	0.074	0.099
Upward from horizontal surface	0.011	0.032	0.055	0.081	0.108

These figures are for convection alone and do not include radiation. If the air was in motion he found that the heat loss in still air was increased by the following factor:

$$\sqrt{\frac{35 + v}{35}}$$

in which v is the velocity of the air current in centimeters per second. The values observed by Langmuir

do not form a smooth curve, those in the column headed 100 deg. forming a hump. It might be that additional points would show an error at this point or a reverse curvature. However, it is to be considered that the study of the phenomena of heat is extremely difficult, even in the best equipped laboratory, owing to the difficulty of obtaining a sufficiently close control of temperature conditions for a sufficient length of time to insure the accuracy of the determination and at the same time to eliminate extraneous factors. Langmuir's work is probably the most accurate now available.

It is rather interesting to see how the emissivity factor 0.0003 as well as those of Langmuir agree with current practice in regenerators. For a temperature difference of 150 deg. the first constant figures out:

$$0.0003 \times 150 \times \frac{10,000}{1,000} = 0.450 \text{ kg. cal. per m}^2 \text{ per sec.}$$

Langmuir's correction for an air velocity of four meters per second would be 3.50, making the emissivity 1.57 kg. cal. per m² per second. Taking the emissivity values of Langmuir and assuming that they apply to equal temperature differences at higher points on the temperature scale, the value of the convection will approximate 0.84 kg. cal. per m² per second.

The heat exchange loss from gas to air or from gas to gas in regenerators generally involves a difference of 300 deg. or more. Comparatively few furnaces or checker chambers are properly insulated to conserve heat. Rule of thumb or "The John Doe Company did it" has established a precedent, and comparatively few analyze the problem to discover the reason or the lack or reason in back of what was done.

The radiation question is interesting. The formula for the radiation loss is:

$$Q_R = 1.41 E 10^{-12} (T_2^4 - T_1^4)$$

In which:

Q_R = The radiation in gramme cal. per sq. cm. per sec.

E = The emissivity of the body.

T_2 = Absolute temperature of hot body.

T_1 = Absolute temperature of cold body.

Radiation takes place from one body to another through a vacuum or a gas. In the physical experiments to determine the coefficient of radiation, the absorption of the radiant heat that takes place in the gas separating the two bodies is a very small portion of the total heat transferred. Radiation curves for different temperature differences may be found in Bulletin 8 of the Bureau of Mines. One of these charts shows that an air space is not as advantageous as 2 inches of brick when the hot surface exceeds 352 deg. or as 4 inches of brick when the hot surface exceeds 227 deg. Two inches of infusorial earth are equivalent to from 10 to 12 inches of brickwork and would be better than an air space when the hot surface ex-

ceeds 100 deg. Radiation plays a very important part in reducing the heat restivity of practically all refractories as the heat passes across the small voids by radiation and tends to equalize the temperature from one side of the brick to the other faster than when conduction only is considered. Radiation also tends to equalize the temperature of two walls separated by an open space and is equally efficient horizontally or vertically. This tends to equalize the heating and cooling of checkerwork openings.

A luminous flame possesses a certain amount of emissivity, due to the incandescent carbon, etc., floating in it. Where the flame is opaque its temperature may be measured by the optical pyrometer, but where the gases are transparent the radiation from the oppo-

site wall of the furnace is measured. Where the gases contain floating carbon or soot it appears to act as a yellow screen and the radiation from the opposite wall will give a slightly higher indication than a pyrometer couple in contact with the gases.

From a radiation standpoint the emissivity of the ideal black body is unity, and that of all other emissivity constants are less than unity. Light colored surfaces have a lower emissivity than dark surfaces. On this account it might be desirable to use light colored paints and light colored brick to reduce the radiation loss. However, there might be certain disadvantages in light colors around furnaces. Radiant heat is one of the most wonderful phenomena of nature.

Liquid Ferro-Manganese in Open Hearth

Ferro-manganese Saved by Liquid Addition to Bath for the Purpose of Reducing — Steel More Uniform, Heat Time Shortened, Temperature Lowered and Production Increased.

By E. C. HUMMEL,

Superintendent Electric Furnaces, United Alloy Steel Corporation.

The practice of adding ferro-manganese to the steel bath for the purpose of reducing it, instead of the former generally employed method of using solid ferro-manganese, was first instuted in Germany. Because of the several advantages of this practice, a number of their works have adopted it. They enumerate these advantages as follows:

- 1—An appreciable direct saving in ferro-manganese.
- 2—The steel is more uniform.
- 3—The time of the heat is shortened.
- 4—The temperature of the heat may be kept lower.

For very obvious reasons, they have chosen to smelt the ferro-manganese in electric furnaces and have used throughout 11 of their works five different types of such furnaces. Regarding the respective merits of these furnaces we are not concerned. But in view of the fact that the above claims have been made, it may be interesting to know the experience and observations made by one steel company in this country which has for the past several months been using liquid ferro-manganese in connection with one of its open hearth plants.

Before taking up the discussion as to the relative merits of the practice, some data and information concerning the operation of the electric furnaces used, will be given. As these furnaces are exactly similar and are operated in the same manner, figures pertaining to one furnace will be sufficient to give an idea relative to lining, costs, capacity, etc. These furnaces are of the single-phase, bottom electrode type and are run on a basic lining. A bottom of burnt magnesite

was sintered in. There seems to be a question regarding this in the minds of some operators of this type of furnace, believing that the water-cooled bottom electrode cannot be used to form an arc with the top electrode on account of melting too easily. Directly, that is a fact. However, by making a few adjustments and using the bottom electrode as a part of the circuit instead of a terminal, this difficulty is overcome, and a bottom of any depth may be sintered in. At the time of this writing over 400 heats have been tapped from such a lining, extending through an operating period of nearly 20 weeks.

The furnaces just described are one-ton furnaces; however, the size of the charge usually depends upon the amount of ferro-manganese ordered by the open hearth melter. It is not unusual to melt five tons of ferro-manganese in a period of 24 hours, this meaning from 6 to 11 heats, depending upon manganese specifications. The average time required to melt a ton of ferro-manganese and have it in shape to tap is about an hour and a half. However, several factors enter in this interval of time which materially effect it. They are as follows:

- 1—Size of ferro-manganese charged.
- 2—Temperature of furnace at charge.
- 3—Shape of electrode.

Fine ferro-manganese or large lumps do not melt as readily as pieces about the size of an apple. A thin-pointed electrode nearly doubles the time required to melt a charge. The temperature of the furnace at charge is important, as a cold furnace absorbs heat which otherwise would appear in the bath. In

considering the quantity of ferro-manganese melted in a 24-hour period, it must be remembered that the melting furnace is constantly working under a certain disadvantage in this respect. The open hearth heat may come faster or slower than the melter anticipates when he orders the liquid ferro-manganese. This may find the electric furnace not ready to tap or else require it to hold the heat. Or the open hearth heats may not be scattered, tapping at such time that it is impossible to supply all of them. These occurrences are almost daily and have the greatest influence on the quantity of ferro-manganese melted per 24-hour period, because they determine the interval between heats. For that reason striking an average time through several 30-day periods, including delays for repairs, a heat is tapped about once every four hours. Any necessary repairing to electrical equipment, water piping or hearth is usually made in the interval between heats, so that an absolute shutdown for any length of time is not required. Under such conditions practically continuous operation can be maintained, as the furnace at no time has required extensive repairs.

The following items pertaining to the melting cost of ferro-manganese are based on actual operation, extending over an interval of four months in which an average of 70 tons were melted during each 30-day period:

Labor	\$ 8.55 ton.
Power	9.55 ton.
Electrodes	3.00 ton.
Refractory cost	2.90 ton.
Repairs to mechanical and electrical parts	1.22 ton.
	<u>\$25.22</u>

This data was not considered under the most favorable conditions, but is simply an average taken over the first four months of actual operation. It goes without saying that the above is daily being improved upon, and it is the writer's opinion that a figure as low as \$15 to \$20 will soon be reached.

The crew on both shifts consists of a melter and two helpers. The work done by them includes all pit labor, the supplying of ferro-manganese, as well as all necessary furnace repairs. It has been found that the results are better by employing two helpers than depending upon the yard labor gang for incidental work, and using one helper.

The power consumption per ton varies between 900 and 1,400 kw-h, depending upon the length of time the heat is held in the furnace. The closest coöperation is required with the open hearth in order to keep this as low as possible. The power factor is about .70 under normal load, operating at 90 volts. The design of the furnace accounts for the low power factor. Assuming normal load at approximately 5,000 amperes and taking the tapping temperature at 2,850 deg. F., an average efficiency of nearly 50 per cent is approached.

An 8-inch amorphous carbon electrode is used, as better results are obtained in this work than by using

a 6-inch graphite electrode for which the furnace was designed. In a furnace of this type and size the umbrella effect produced by the arc must be considered as the life of the roof is materially effected by it. This effect depends entirely upon the cross-section of the electrode at the place where the arc is struck. The 8-inch amorphous carbon does not become pointed as soon as the 6-inch graphite, which advantage decreases the time of melt, neither is the breakage loss as high. The electrode consumption averages 33 pounds per ton, which includes the stumpage loss.

The refractory cost is dependent entirely upon the prevailing furnace practice. In this work, it is most advantageous to use a thin coke and silicon slag, which reduces the tendency of the ferro-manganese to oxidize and at the same time protects the roof and sidewall. However, the main refractory cost lies in the relining of the roof, 70 to 100 heats being obtainable on one lining. By using a simple 10-inch jacket cooler on the roof, the life of the roof is lengthened and excessive heating of the electrode prevented.

In discussing the practice of adding liquid ferro-manganese to the steel bath, the one outstanding advantage is the direct saving in the quantity of the ferro-manganese used per ton of ingot. Figures submitted by the metallurgical department show this to vary from 5 to 30 per cent, depending upon the kind of steel being made. Considering the present and recent market prices of ferro-manganese, the saving has been from 20 to 75 cents in the cost per ton of ingot produced. However, it is not wise to attempt to carry this saving too far. It must be remembered that the liquid ferro-manganese is poured into the ladle while the metal bath is being tapped and the time allowed for reducing the steel is very short indeed. When working with solid ferro-manganese it is usual to wait about five to eight minutes after the addition before pouring it into the ladle so as to give the ferro-manganese sufficient time for reduction. When putting the liquid ferro-manganese into the ladle, this time is shortened, with the result that a higher output is obtained. If the quality of the material produced is influenced by unsufficient reduction, this increase in output is then an expensive thing. But no bad effects have been found in the quality of the material, but rather an improvement, while the saving in ferro-manganese and time has been pronounced. Concerning the temperature of the heat, there is no difference in either practice.

The question in conclusion now arises as to what effect the return of ferro-manganese to its normal cost in the future will have on the successful carrying on of this practice. The saving in ferro-manganese will still go on, but its appreciable effect in reducing the cost per ton of ingot will be materially lessened. However, by that time the melting cost, due to experience and coöperation will be lowered to a degree which it is hoped will strike an even balance.

Electric Skip Hoists for Blast Furnaces

General Conditions and Requirements of Furnace Hoists—Direct Current Machines, Including Geared and Gearless Types—Description and Operation of Alternating Current Furnace Hoists.

By DAVID L. LINDQUIST.

Not very long ago the alternating-current furnace hoist was considered in the experimental stage, but recent developments in the design of the alternating-current apparatus has resulted in the successful and advantageous use of ac for operating these machines. It is therefore the intention in presenting this paper to summarize the various points already mentioned and to point out additional features and new developments of both alternating and direct-current apparatus, together with some results obtained from actual tests of alternating-current furnace hoist installations.

In order to make a more comprehensive presentation of the subject it is necessary to include in more or less detail many of the features which have already been fully covered by the previous paper.

The subjects to be considered are as follows:

1. General conditions and requirements of furnace hoists.
2. Direct-current machines, including geared and gearless types.
3. Description and operation of alternating-current furnace hoists.
4. Bell hoists, including crank and drum type machines, and a comparison between these types.
5. Comparison between direct-current and alternating-current furnace hoists in regard to their operation, reliability, and maintenance of service.

Furnace Hoists—Conditions and Requirements.

The first consideration is to fully ascertain and determine all of the conditions and requirements relating to the furnace hoist equipment.

While it is apparent that there is a wide variation in the conditions and requirements to be met in furnace hoist service, the importance of many of these conditions is perhaps not generally realized. It is well known that there is a wide range in the loads to be hoisted during normal operation. During abnormal operation a still further variation is found in that it may be required to hoist an empty skip or lower the maximum load. In addition we have the single or double skip type of hoist each with its various loading and dumping arrangements.

First part of paper read by the author before the Pittsburgh section of the A. I. S. E. E., February, 1918.

First in order are the conditions to be met in starting.

A load diagram for a double skip indicates that when starting from limits of travel, the load is greater than when running. This is due to the loss in effective weight of the empty bucket in its dumping position, where one bucket does not balance the other. The effect of this unbalance naturally increases the load on the machine and motor, and the percentage of increase depends upon the track arrangement at the top; the dumping angle of the bucket and the relative position of the head sheave. In order to select the motor with a sufficient amount of torque to start and

accelerate the entire moving mass, it is necessary to lay out a load curve for each particular dumping arrangement.

Load diagrams for two single skip installations are shown by Figs. 2 and 3. Fig. 2 shows a generator load at the start, which, however, is not greater than the normal running load.

The points have been mentioned merely to emphasize the fact that the starting loads must be determined in each particular case.

The next point to be considered relates to the conditions of stopping. These are usually of more importance than the starting conditions. Further examination of one of the single skip diagrams, Fig. 3, indicates that here the loads in the stopping zone first change to generator and then to a motor load when the charge in the bucket is lowered into the furnace top.

Irrespective of the different loads and arrangement of loading and dumping, it may be stated generally that the more important requirements are continuous, safe and uniform operation.

Continuous operation means 24 hours a day for a number of years with no time available for an extended shutdown. This not only implies rugged and simple construction, relatively high factors of safety and provision for quick replacements, but makes the adoption of these features necessary for successful operation.

Safe operation means principally that in stopping, the bucket must travel a sufficient distance to prop-

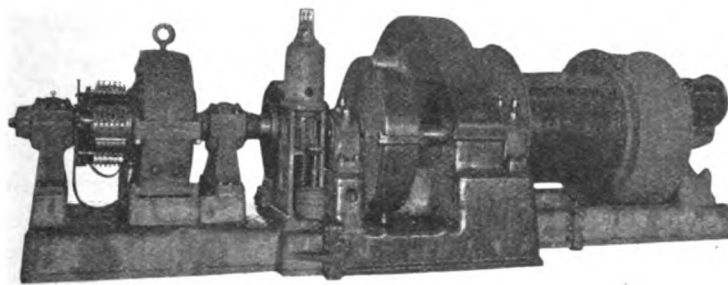


Fig. 1.

erly dump the load, but must not travel far enough beyond this point to result in damage to the furnace top or pull out the ropes. This requirement is impor-

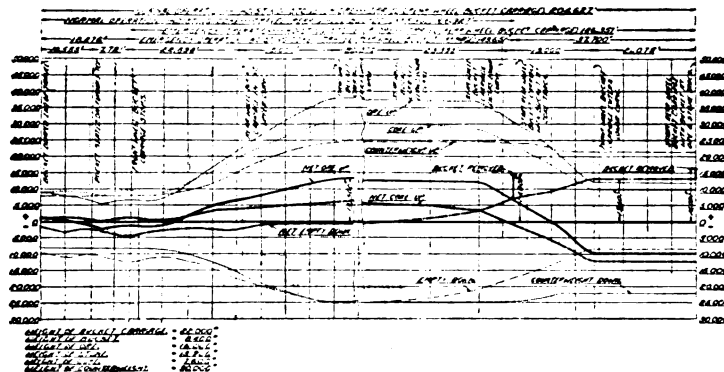


Fig. 2.

tant because in the majority of cases the distance available for overrun is very limited.

Uniformity of operation means uniform starting, acceleration, running and especially stopping with the various loads that have to be handled. This last requirement is also essential for safe operation.

Another point to be considered is the speed at which the loads must be hoisted. The increased output of the modern blast furnace has made it necessary to operate the machines at a much higher speed than formerly. It may be of interest to know that electric machines are now being built to give hoisting speeds of 600 r.p.m. The higher running speed results in greater wear on the mechanical parts; requires more accelerating force, thereby placing increased strains on the machine; and most important of all, makes it more difficult to obtain accurate stops. The high speed requires additional refinements of the speed control in order to obtain accurate stops.

Direct Current—Furnace Hoist Machines.

The earlier type of direct-current furnace hoist machine consisted of a high speed motor, magnet brake, solid coupling, two reductions of spur gears and one or more drums.

The use of a high speed motor resulted at times in gear vibration which was apt to cause damage to the motor and other parts. In the more recent types of geared machines, as shown by Fig. 1, several im-

provements have been made in order to reduce this vibration. One of the more important of these changes is the use of herringbone gears instead of spur gears, as the smooth action of the herringbone gears very materially reduces vibration. Another important change is the use of a flexible coupling between the armature shaft and pinion shaft, thereby reducing to a minimum the amount of vibration transmitted from the gears to the motor. In the effort to eliminate excessive wear, oil-tight gear cases have been provided together with dust guards over exposed parts; the object being to keep oil in and dust out. The necessity of making provision for quick replacements has brought about the use of removable bearing sleeves, which can be taken out and replaced without removing the shaft. In addition the flexible coupling is so designed as to permit removal of the armature from the bearings without disturbing the brake or brake setting. The latest type of direct-current furnace hoist machine is the gearless. Although the herringbone gears

are a most suitable means for obtaining a speed reduction between the motor and drum, it is possible with direct-current to eliminate all gears by the use of a slow speed motor.

A gearless machine in which the driving sheave is mounted directly on the armature spider has already reached a high state of development in its application to high speed elevators, and it only remained to adapt

this arrangement to furnace hoist service.

This machine as designed for blast furnace service can be best described by stating that it consists of a

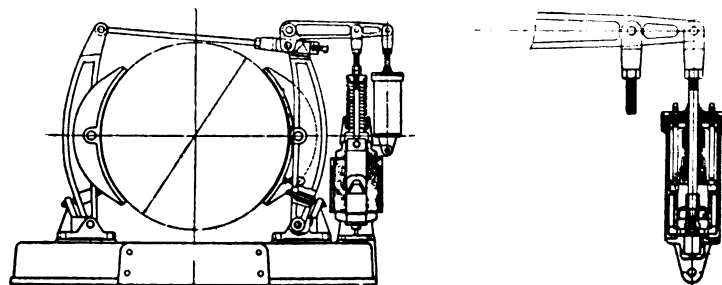


Fig. 4.

motor, brake, and one or more drums mounted on an extension of the armature spider. Where conditions are suitable, traction drive may be used instead of

drums. A machine of this type to operate successfully involves the proper design of a comparatively slow speed motor, and in a particular case requires a motor of 180 hp output at 38 r.p.m. maximum, and Fig. 5 showing the characteristics of such a motor indicates a high efficiency.

Contrary to the general impression, it is not only possible to build an efficient and reliable slow speed dc motor to operate a hoisting machine, but numerous elevator installations giving satisfactory service, offer the best testimony to the truth of this statement.

Reference to the general arrangement of the gearless furnace hoist machine will show the extreme simplicity of construction and minimum number of parts subjected to wear. As a matter of fact, since there are only two bearings, it is evident that with reference to wearing parts, we have reached the "irreducible minimum."

Mention should be made of the brake used and the development of an oil dash pot that makes it possible to instantly apply the brake with a predetermined amount of initial pressure, and permits of quick but gradual application of the full pressure.

The dash pot is designed in such a manner as to allow the use of a very loose fitting plunger, because the retardation is required for only a very small fraction of a second. As the plunger has a very loose fit and the dash pot is entirely enclosed so that no foreign substance can get in, it makes it impossible for the dash pot to stick. Further than this, even a considerable amount of wear of the rubbing surfaces will not materially affect the proper action of the dash pot. It may be mentioned that a mineral oil is used in the dash pot which is perfectly stable and has a very low viscosity, thereby giving a practically constant retarding effect, irrespective of temperature changes to which the dash pot may be exposed.

Fig. 4 shows this brake which is of the shoe type and is applied directly on the drum by spring pressure. It is released by an electro-magnet. While we might elaborate upon other features of the gearless hoist it is sufficient to state that it represents the latest type of the direct-current hoisting machine.

Operation of DC Furnace Hoist Machine.

The dc current hoist machine of either the geared or gearless type is operated by a motor, brake, master switch, stop-motion switch and controller. The motor is of the multi-pole, compound wound type with interpoles and of liberal design for the continuous duty. The series field is used only during acceleration and slow down and is short-circuited when the motor runs at full speed.

The brake is released by an electro-magnet and is spring applied as mentioned before.

The master switch is the means provided for the operator to run the hoist. A stop-motion switch is used for slowing down and stopping the hoist at limits

of travel independent of the operator. This switch is operated through gearing from the drum shaft.

The controller consists of slate panels on which are mounted a number of electro-magnet switches to control the acceleration, running, slowing down, and stopping of the motor. Speed control of the motor is obtained, first, by field control and, second, by resistance in series and parallel with the armature.

Alternating Current Furnace Hoist Machine Description and Operation.

The application of alternating-current for a geared furnace hoist machine is a comparatively recent development. The mechanical parts of the machine include all of the latest improvements of the direct-current geared machine, such as herringbone gears, oil-tight gear cases, flexible coupling, removable bearing sleeves, etc.

Up to the present time, a gearless alternating-current machine has not been considered feasible due to commercial limitations, as the size and cost of the alternating-current motor for the extremely slow motor speed required with this type of hoist would be prohibitive.

The alternating-current geared furnace hoist machine is operated by a motor, brake, master switch, stop-motion switch and controller.

The motor used is of the two-speed slip-ring induction type, with two windings on the rotor. The conditions requiring a two-speed motor for furnace hoist service will be described later. One stator winding is called the fast-speed and the other the slow-speed winding. The same designations apply to rotor windings. These windings are so made that with the line connected to one stator winding the motor will run at a certain definite speed, while with line connected to the other stator winding, the motor will run at another definite speed. The ratio of the fast to the slow-speed is usually 5 to 1 or 6 to 1, but this ratio may be as great as 10 to 1 if conditions demand this amount of speed reduction. Should the conditions be such as to require a speed reduction greater than 10 to 1, this can be accomplished by means of an auxiliary device connected to the main machine; or in other words, what is known in elevator practice as the micro drive.

The stator coils of the two-speed alternating-current motor are of the form-wound type and are placed in open slots. The same slots are used for both the fast and slow-speed windings. The coils used for slow-speed are placed in the top of the slots next to the airgap, and those for the fast-speed in the bottom of the slots.

The rotor coils are of the hairpin type and are placed in semi-closed slots. The same slots are used for both the fast and slow-speed windings. The coils used for slow-speed are placed in the top of the slots

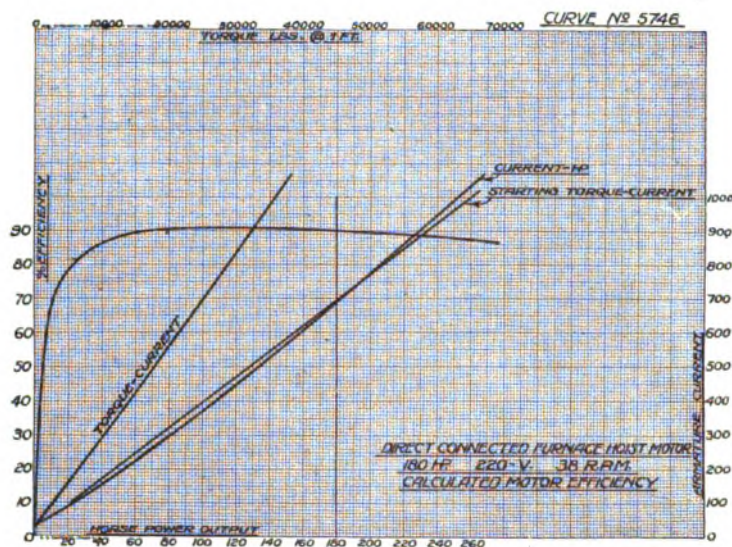


Fig. 5.

next to the airgap, and those for the fast-speed in the bottom of the slots.

The location of the fast and slow-speed coils with reference to the airgap is a matter of design, and we have found that the arrangement just outlined gives the most satisfactory results. The rotor windings are connected to five independent slip rings, insulated from each other and completely insulated from the rotor shaft. One slip ring is common to both rotor windings. The slip rings are used to connect external resistance to the rotor windings as will be more fully described later.

The two-speed motor may be designed to start from rest on either the fast-speed or slow-speed winding, as conditions demand.

It may be interesting to show the characteristics of one of the motors now in actual operation. Fig. 6 shows the performance curves of the alternating-current two-speed motor on fast-speed, and Fig. 7 the starting torque curves on fast-speed.

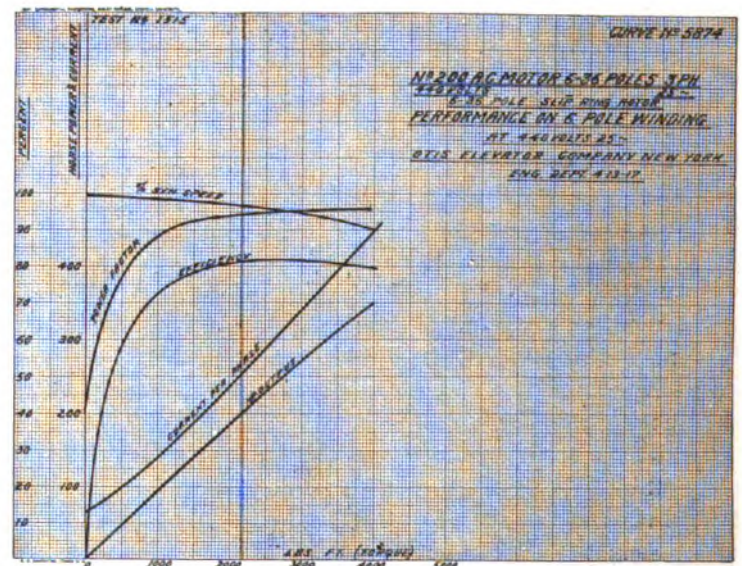


Fig. 6.

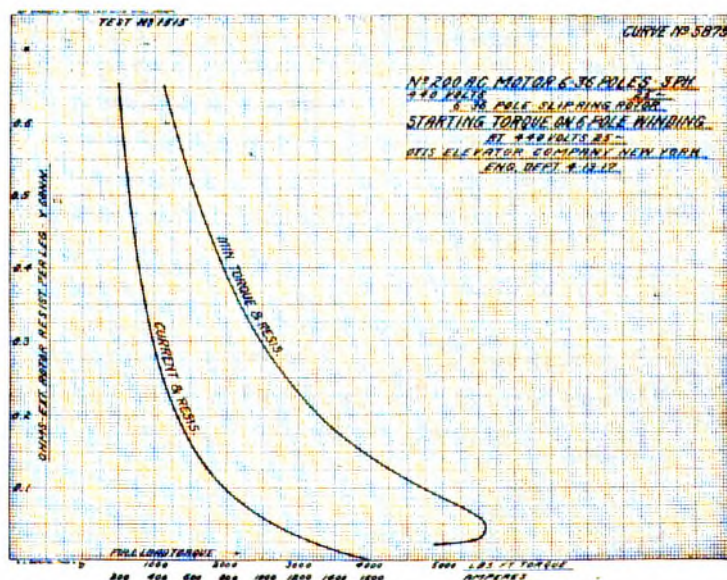


Fig. 7.

Figs. 8 and 9 show, respectively, the performance and starting torque curves on this same motor on slow-speed.

The brake is of the same type and has the same mechanical parts as the direct-current brake. With alternating-current it has until recently been the general practice to use either a brake magnet operated by direct-current or by a small alternating-current motor. Realizing the disadvantages of using direct-current for brake operation with an alternating-current main supply, and considering the disadvantages of the motor-operated brake, a magnet-operated brake using alternating-current, has been developed. A magnet-operated brake possesses several advantages over a motor-operated brake; namely, simplicity of construction, ease of adjustment, quick release and regulation of braking power.

The alternating-current brake magnet has three coils open to the air. These coils are of the shunt

type and depend for their operation on the voltage and frequency of the main line. Anyone of the three coils may be easily removed and replaced. This brake is provided with an oil dash pot and permits of instantaneous application of the brake with a predetermined amount of initial pressure, and of quick but gradual application of the full brake pressure.

The oil dash pot is of the same design as that used on the gearless hoist and is shown by Fig. 4. The master switch and stop-motion switch are of the same type used on the direct-current hoist and for the same purpose. The controller consists of an iron frame supporting slate panels, on which are mounted magnet switches designed to control the operation of the hoist. Two resistance units, one for fast-speed and one for slow-speed, are furnished.

The controller is operated by alternating-current of the same voltage and frequency as used by

the motor. No direct or rectified current is used anywhere in the system. The control magnets are of the single-phase type, with split-phase secondary, and have ample power to make and maintain proper contact pressure. All switches which make and break high current are equipped with carbon to copper contacts for making and breaking the current and separate copper to copper contacts for carrying the current.

The contacts are provided with cushion springs, and are closed when the magnet is energized and are opened by the weight of the contact arms and magnet core when the magnet is de-energized. The switches which break high currents have magnetic blowouts.

The switches on the controller are as follows:

Potential switch; reversing switch; fast and slow-speed switch; three accelerating switches for slow-speed rotor; six accelerating switches for fast-speed rotor; overload switch; reverse phase relay.

The potential switch and reversing switches are operated by the master switch and close and open the circuit to the motor and brake, not only during normal operation from faster switch and stop-motion switch, but also upon the operation of any of the safety devices such as limit switches, slack cable switch, reverse phase relay, etc.

The fast and slow-speed switch is also operated from the master switch, and has two sets of contacts. One set, which controls the fast-speed stator winding, is mounted on the upper end and the other set, which controls the slow-speed winding, is mounted on the lower end of the pivoted arm. The switch is so arranged that the upper set of contacts is closed when the magnet coil is energized, and the lower set is closed only when the magnet is de-energized, at which time the weight of the magnet arm and core, operating by gravity, makes certain that the upper contacts break and that the lower contacts make. From this it is evident that the motor is connected for fast-speed only when the fast and slow-speed switch is energized and is connected for slow-speed only when this switch is de-energized. A wiring diagram of the main line stator circuits is shown by Fig. 10.

In describing the general features of the motor, mention was made of the fact that the stator windings are connected in series. This series arrangement of the windings consists of connecting one phase of the slow-speed stator winding in series with the corresponding phase of the fast-speed stator winding.

In the case of a three-phase motor, the three sets of two windings in series are star connected, the fast-speed winding being on the inside of the star. In the case of a two-phase motor the two

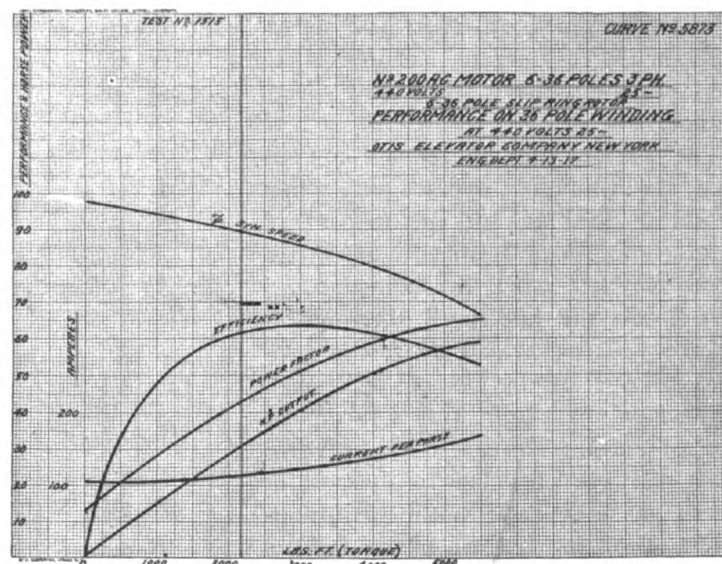


Fig. 8.

sets of two windings in series are L connected, the fast speed windings being on the inside of the L. The fast or slow-speed connection is made by the fast and slow-speed switch as follows:

When this switch is de-energized the fast-speed windings of the motor are short-circuited and the slow-speed windings are connected in star or L. When this switch is energized the slow-speed windings are short-circuited and the high-speed windings are connected to the line, this winding being permanently connected in either star or L. Mention should be made of the fact that either the fast or slow-speed stator windings may be delta connected.

There are two sets of accelerating switches; one set for fast-speed and one for slow-speed. These switches are used for short-circuiting the starting resistance which is in series with each rotor winding. The accelerating switches for slow-speed, three in number,

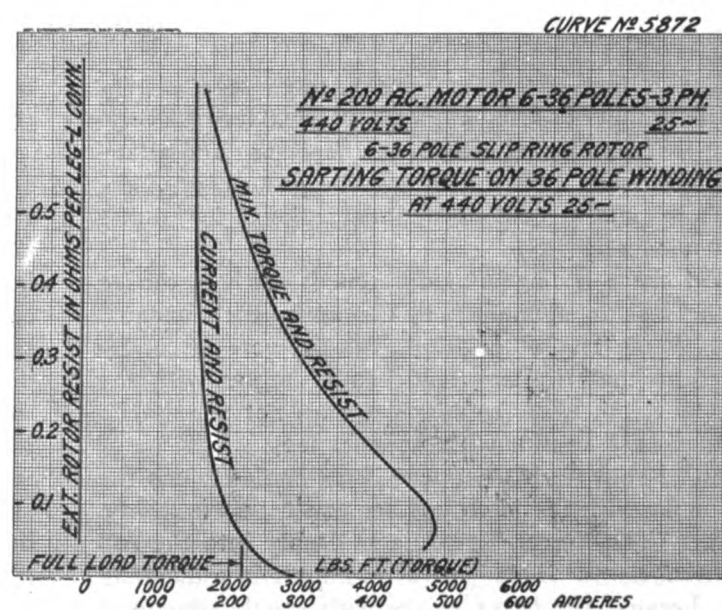


Fig. 9.

operate only when the stator windings of the motor are energized in the slow-speed connections. These switches operate successively one after the other, short-circuiting the slow-speed starting resistance.

The accelerating switches for fast-speed, six in number, operate only when the stator windings of the motor are energized for the fast-speed connection. These switches work in sequence and short-circuit the fast-speed starting resistance. The overload switch is provided to operate in case of excessive overload on the motor, and is furnished with an automatic reset. The reverse phase relay is provided to operate in case of phase reversal of the main supply lines, or in case of phase failure. This switch operates each time the hoist is started and stopped.

The operation of the controller, motor and brake for a complete trip of the hoist may be summarized as follows:

The controller is so arranged that the motor can be started from rest on either fast or slow-speed, depending on the will of the operator, or, it may be arranged so that the motor can start from rest on slow-speed only.

Assuming that the conditions permit starting on

fast-speed, the operator throws the master switch handle to the extreme position.

The potential switch, reversing switch and fast-speed switches are energized, admitting current to the fast-speed motor winding and to the brake magnet.

The brake then lifts, the motor starts, and accelerates to full speed as the rotor resistance is short-circuited. The hoist then runs at full-speed until it approaches the dumping zone, at which point the stop-motion switch interrupts the circuits of the fast-speed coil, causing this switch to be de-energized, thereby changing the motor from the fast to slow-speed connection. When the slow-speed winding is energized the slow-speed rotor resistance is gradually short-circuited by the action of the accelerating switches already described. When this resistance is entirely short-circuited the motor runs at slow speed.

The length of time during which the motor may run at slow-speed depends upon the requirements of the particular dumping arrangement used, and the controlling equipment must always be arranged accordingly.

Just before limit of travel is reached the stop-motion switch contacts open the circuits of the reversing and potential switch coils, thereby cutting off all current from motor and brake magnet, causing the brake to be applied and stopping the hoist.

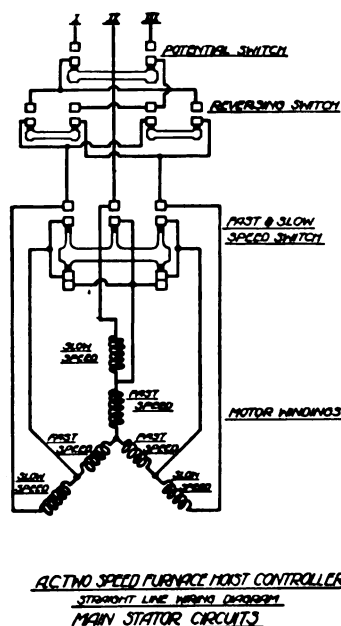


Fig. 10.

Elements of Roll Pass Design

The Rolling of Angles With Unequal Legs—End Thrust to Be Considered—Angles With Unequal Legs Should Be Placed Differently in the Finishing Passes Than in the Roughing Passes.

By W. TRINKS.

The rolling of angles with unequal legs is very similar to that of rolling angles with equal legs. Everything that was stated concerning necessary and allowable reductions, and concerning the protection of the edges by lateral compression holds good for angles with unequal legs.

Yet there is one vital difference which is caused by the lack of symmetry in the angle with unequal legs. With the other kind, passes were naturally placed so that the legs made equal angles with the pitch line, but that arrangement does not necessarily produce best results with unequal legs.

Fig. 1 shows what happens if the angles which the legs make with the pitch line are equal, that is to say, 45 deg. The longer leg projects deeply into the roll and weakens it. This is of little import in a finishing pass, because the latter works with small reductions,

but it would be a more serious matter in a roughing pass, on account of the greater draft.

The second harmful effect of placing the pass, as shown in Fig. 1, is end thrust. The force between the stock and the rolls is normal to the surface of contact and is roughly proportional to the displaced area. This means that the resulting force on the long leg is considerably greater than the resulting force on the short leg. Fig. 1 shows that the components in the direction of the roll axis are not equal, so that a considerable end thrust is set up. Again this is of minor importance in a finishing pass on account of its small reduction, but is undesirable in a roughing pass.

On the other hand, the arrangement of Fig. 1 has the advantage that an adjustment of the center distance between the rolls changes the thickness of both legs the same amount. This, again, is a great advantage.

tage in the finishing pass, because there close adherence to correct dimensions is necessary, but is of little use in a roughing pass. It is, therefore, easily seen that the arrangement of Fig. 1 is well adapted to use in a finishing pass, but is not suitable for roughing passes.

Fig. 2 shows the arrangement of the angle as it is commonly used for roughing passes. Both legs now extend the same distance into the roll. The roll is weakened to a smaller extent, because the long leg projects less deeply into the roll than it does in Fig. 1. There is practically no end thrust, for although the force on the longer leg is greater than that on the short leg, it acts more directly towards the roll center, so that the components in the direction of the axis

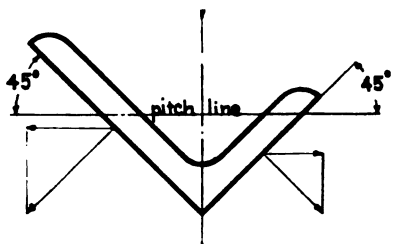


Fig. 1—Method of placing angle in finishing pass.

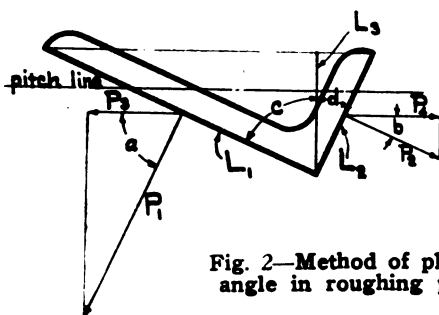


Fig. 2—Method of placing angle in roughing pass.

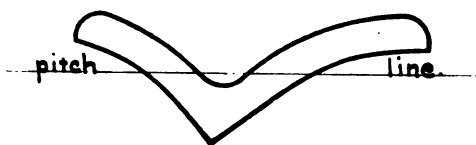


Fig. 3—Roughing pass for angle with unequal pass.

are equal and opposite. Mathematical proof of their equality is as follows:

Let pressure per unit length of the legs be p . Then in Fig. 2 $P_1 = pL_1$, and $P_2 = pL_2$. But $L_1 = \frac{L_3}{\cos c}$ and $L_2 = \frac{L_3}{\cos d}$. $P_3 = P_1 \cos a$, and $P_4 = P_2 \cos b$. From this we get $P_3 = pL_1 \cos a$, and $P_4 = pL_2 \cos b$; hence $P_3 = pL_3 \frac{\cos a}{\cos c}$, and $P_4 = pL_3 \frac{\cos b}{\cos d}$. But angle c equals angle a , since their sides are perpendicular; and similarly, angle $b =$ angle d . $\frac{\cos a}{\cos c} = 1$, and $\frac{\cos b}{\cos d} = 1$. Hence the horizontal components P_3 and P_4 are equal.

On the other hand, the arrangement of Fig 2 is not suited for finishing passes. For, if the distance between the rolls be varied for the purpose of adjustment of the thickness of the angle, the variation of the thickness is greater on the long leg than it is on the short leg.

From this reasoning follows the rule that angles with unequal legs should be placed differently in roughing passes from what they are in finishing passes. In roughing passes the two legs should extend the same distance into the roll, whereas, in finishing passes the two legs should make equal angles with the pitch line.

The same reasoning holds true, if the angles are rolled by the butterfly method. Fig. 3 shows a roughing pass on the butterfly principle. There is practically no end thrust, and the rolls are weakened even less than they are in Fig. 2.

As mentioned before, there is some end thrust in finishing passes where the structural angle is placed so that both legs make 45 deg. with the pitch line. The end thrust is taken care of by making the rolls interlock; that is to say, by putting collars on the rolls so that they act as thrust bearings. (See Fig. 4.) From the very nature of these collars it follows that they cannot be an absolutely tight fit. There is a slight amount of lost motion, which means that the reduction on the long leg is less than was intended, while

the short leg is reduced too much; because the greater reaction of the long leg in the axial direction moves the roll lengthwise so as to diminish this force, by making the reduction of the long leg less. To counteract this tendency, the apparent reduction on the long leg is made slightly greater than that on the short leg. The difference is about one-thirty-second inch,

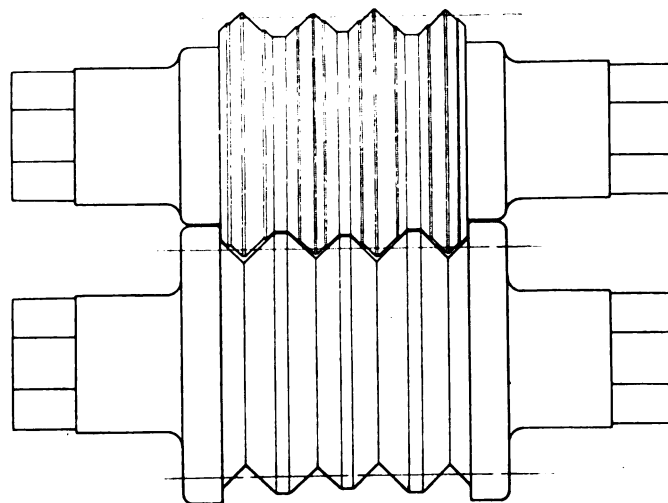


Fig. 4—Finishing rolls for angles with unequal legs showing thrust collars.

and is equalized by the play between the collars.

No passes for Z-bars will be considered in these articles, because Z-bars may be considered as built up of two angles.

Standardization of Steel Industry Motors

Standardization Committee of A. I. S. E. E. Endeavoring to Formulate a Plan That Will Ultimately Give the Steel Industry Motor Standardization Which Will Have Economical Advantages.

In the early days of electricity in the steel industry some of the builders of traveling cranes made the motors for their crane. This practice is now obsolete by virtue of specialization and standardization. Motors are made by motor manufacturers, cranes by crane builders, each a specialized apparatus, requiring specialized organization and manufacturing equipment. Crane users in the steel industry now select the motors for their cranes, and, as far as they are able, standardize on a certain type and make of motor for the sake of interchangeability and minimum of spare parts, which is desirable from the standpoint of less confusion, smaller investment, and greater reliability, and applies to motors in general, for cranes, mill auxiliaries, machine tools, etc.

Because of the fact that there is no standardization or uniformity in motors of like operating characteristics made by the different manufacturers, there can be no interchangeability of motors of different makes. The result is that a certain manufacturer's motor is used in individual plants to the exclusion of all others, depending upon which make of motor was selected for the initial installation.

The individual plants of the industry, therefore, have two alternates; of (a) adopting a certain make of motor and enjoying the benefits of standardization as far as they are able under existing conditions, thus eliminating competition, or (b) buying motors in open competition based on price and reliability, making no attempt at standardization and being content with a conglomeration of motors of different makes, with resultant complexity and confusion and excessive investment in necessary spare parts. There are many benefits to be derived from a standardized motor, apparent to all mill designers, motor users, and manufacturers who have experience.

The A. I. & S. E. E. through its standardization committee has for some time past been endeavoring to formulate a plan that will ultimately give to the industry a standardized motor for machine tools and mill auxiliaries.

It is a task that cannot be accomplished hurriedly and it is doubtful whether it will ever be accomplished by following plans originally determined upon; that of inducing the manufacturers, when they bring out a new line or a modification of their old line of motors, to adopt certain standards that will result ultimately in uniform general characteristics and dimensions to the extent of interchangeability as a complete motor, one manufacturer's motor with another.

That this would be a decided benefit over present conditions must be conceded; whether it would be entirely satisfactory when accomplished is questionable, and it has been suggested that the next consideration would be interchangeability of parts.

The standardization committee of the A. I. & S. E. E. is now studying the advisability and the possibility of a joint committee of engineers, representing makers and users, designing a line of standard motors which all manufacturers would be asked to build.

From the standpoint of standardization and utilization the result would be ideal; the extent to which it would interfere with development must be carefully considered. Few stop to consider the advantages of standardization as it exists with screws and bolts, lamp bases and receptacles, railroad track gages and train couplers, the Liberty motor and the Liberty truck. The many benefits derived compared to the disadvantages resulting therefrom is apparent to all.

It has been said that standardization would result in stagnation or retardation of research and development. This need not be true, for as the state of the art demands modification of motor design, let it be done according to prearranged standards. This would tend toward stabilizing development and eliminate the present tendency of changing designs without notice, oftentimes seemingly for no other reason than to do something different.

Specific reference is made to a construction job involving a large number of motors, the job requiring about two years' time. When the job was about 80 per cent complete the line of motors, upon which it was decided to standardize, was taken off the market and another type had to be used, and in spite of the care used to have a good installation with a minimum of spares, the job finished up with a mixed motor installation, and with additional spares that would not otherwise be needed, representing an added investment that will more than counteract any improved economy or increased efficiency that the new line of motors would affect. The new motors are no more reliable than those abandoned and reliability is the first consideration in the steel industry.

That the manufacturers could not at this time make any change that would interfere in the least with maximum production is thoroughly appreciated. That much preliminary work that will require much time must be done before even a pattern is made for a standardized motor is also fully realized.

If, however, in one, two or five years from now

we could begin to install motors that would adhere to standards covering only speeds and general dimensions, we would have begun to right a wrong condition and the benefits would increase with time as new standard motors superseded and replaced the present individualistic motor.

Based on data by Wiley & Sykes, A. I. & S. E. E. proceedings, 1915; also on data from a four-blast furnace plant making iron into finished product, fairly modern with regard to motor-driven auxiliaries; also on data from the United States Bureau of Census there should be in the iron and steel industry approximately 800,000 motors; including allied industries the total would approach 1,000,000 motors.

Allowing these 1,000,000 motors a liberal life expectation, they will probably all be charged off and most of them replaced in 20 years, particularly when we consider that a large proportion of present direct-current motors could be alternating-current, and are likely to be replaced eventually, because of the higher economy in ac power generation and transmission which is tending toward obsolescence of dc generating equipment and making ac motors desirable where they can be used, and the fact that the field of the ac motor is continually expanding and crowding out the dc motor.

With 1,000,000 motors in operation a fair estimate would be 500,000 armature changes, and 200,000 spares required, averaging 20 hp per spare and valued at \$15

per hp would represent an investment of \$60,000,000.

With 1,000,000 motors in operation and standardized to the extent of interchangeability only about 50,000 spares, valued at \$15,000,000, would be required.

It is reasonable to expect that attention concentrated on a single line of motors by all concerned would result in a motor more rugged than if this attention were divided by 50 or more, as is the case at present, and it is likely that with such concentration motor improvements and development would approach that of the incandescent lamp, the most standard and highly developed electrical commodity that we have.

It is likely that a standardized motor would become more highly developed, more economical to manufacture, result in better deliveries, less confusion in selection and maintenance by the user and greater reliability in operation, which is generally the most important factor.

The first step would seem to be to give full consideration to all points involved, then decide if we can what is best to do; whether it would be better to have a standard motor, even though the design of tomorrow would be rendered obsolete by development, and a complete new motor be necessary at the end of 2, 5 or 10-year periods, but still be a standard motor; or, whether the present conditions will continue and each manufacturer adhere to his own standards and bring out a complete new line of motors at the end of the same periods, a complete departure from his own and conforming to no existing standards.

Telautographs Expedite Steel Production

The Use of This Instrument in Transmitting Messages, Analysis, Symbols, Etc., Is of Great Aid in Speeding Up Production and in Accurately Checking Up Orders and Specifications.

By H. C. SNYDER.

There are perhaps a great many people engaged in the manufacture of steel and steel products who have never heard of nor seen the telautograph in operation, and still more who possibly know what it is and yet are unaware of the important work it is accomplishing in increasing the output and building up the efficiency of many of this country's steel plants, large and small. The telautograph is an instrument which instantaneously transmits by electricity written messages or orders in the actual handwriting of the sender. With the telautograph you write over wires just as with the telephone you talk over wires. The telautograph is not limited to the sending of words only, but it can transmit numerals, signs, symbols, sketches or anything else that is written at the transmitting end and accurately reproduce them at the receiving sta-

tion or stations. Furthermore, it can send messages to a single point or simultaneously to any number of stations desired with a single writing of the message by the sender.

How it Applies to the Steel Business.

The best way to describe the application of the telautograph to the process of manufacturing steel is to start with the receipt of a customer's order in the office of a typical plant and trace the various stages in the handling of this order until the finished product has been turned out and the material is ready for shipment.

Practically all orders for iron and steel contain specifications describing just the quantities of carbon, silicon, sulphur, phosphorous and manganese that the material to be delivered on the orders should contain. Each order is given a "heat" number to identify it

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throughout the plant and copies of the order with specifications and "heat" number are sent to the laboratories, blast furnaces, open hearth and Bessemer mixers, soaking pits of the blooming mill, chief recorder of the blooming mill, hydraulic shears, billet and bar mill, breaking down mills and bloom yard office, etc.

First Process.

The manufacture of all steel, of course, starts with the blast furnace and the mixers. A sample of each "heat" from the blast furnace blowers is sent to the blast furnace laboratory for analyses as to its carbon, sulphur, silicon and phosphorus content. Here is where the telautograph starts its valuable work. The blast furnace laboratory, after obtaining the analysis, writes the results simultaneously to telautograph stations at the blast furnace blowers and the open hearth mixers. This is of benefit to the blast furnace because it enables the blowers to know just what kind of iron



Telautograph installed in a steel mill.

they are making and whether they are approaching the specifications, and by obtaining this information in advance the open hearth and Bessemer mixer is able to prepare for handling the ladles when they arrive. The mixer also has occasion to notify the blast furnace by telautograph when the ladles arrive with their surface solidified, so that on future deliveries the blast furnace can put more coke dust on the surface to prevent recurrence of the trouble. Very often the ladles in the journey between the two points are delayed and the blast furnace telautograph sends notice of these delays to the mixer so that other provisions can be made.

Telautographs Distribute Chemical Analyses.

After the open hearth and Bessemer mixers have gotten the "heat" to the approximate proper proportions and have run the steel out into the ingot moulds, a sample of it is taken and sent by messenger to the main chemical laboratory. Here the steel is analyzed and a report of the analysis giving carbon, phosphorus, manganese and sulphur content are transmitted by telautograph simultaneously to the bloom yard office, billet mill, shears, breaking-down mills, and chief re-

corder of the blooming mill. The analyses are reported in the following form:

(Open Hearth Steel).				
Heat No. 13,810	C-.09	P-.016	M-.41	S-.045
(Bessemer Steel).				
Blow No. 74,900	C-.09		M-.43	S-.153

The clerk in the bloom yard office, where copies of all orders are kept and where final authority as to allotment of "heats" to orders exist, immediately compares the analyses with the specifications on his copy of the order for this "heat" number, and if the analysis tallies with the specifications he checks it off and takes no further action. If, however, the clerk finds that the analysis doesn't agree with the order, he looks to see if the steel can be applied on some other order and if successful he assigns the "heat" of steel to that order. If, however, he is unable to find any order on hand that this steel will suit, it is ordered rolled and put in stock.

Telautograph Used to Tally and Direct Progress of Ingots Through Blooming Mill.

A boy in a pulpit about 12 feet above the soaking pit floor has a plain view of all the pits and the first set of rollers through which the ingots pass. He has before him on a blackboard the "heat" number and number of ingots in each pit, so that as soon as a pit door is opened he can tell what "heat" of steel is being drawn out and how many ingots are to be accounted for. The ingots are drawn out one at a time and put on chariots which carry them to the first set of rolls where the ingots undergo their first reduction in size, and as the first ingot reaches there, the pulpit boy writes on his telautograph to the chief recorder, as follows:

No. 1—O. H. No. 6,284—(6) 24 at 40-inch mill now.

Which means that ingot No. 1 of open hearth "heat" No. 6,284, containing six ingots in all and drawn from pit No. 24, is now being rolled at 40-inch mill. To which the recorder replies: "O-K," showing he has received the message. As the second, third, etc., ingots pass through the mill the boy writes, leaving out useless repetition:

2		24
3		24
4		24
5		24
6		24

showing that all ingots of "heat" No. 6,284 have been rolled.

The chief blooming mill recorder, usually located where he has an unobstructed view of the mill and the various rollers, can watch the progress of the ingots as they pass from one set of rolls to another, and by having this information designating the "heat" numbers and the numbers of the ingots being rolled at the set of mills furthest off, he can follow the ingots up and see that they are properly recorded and accounted for at the other mills through which they

pass, thereby preventing the mixing of "heats" by losing the identity of the ingots. This is extremely important because, as explained before, each "heat" of steel is mixed particularly for and assigned to a certain order only after the chemical analysis shows that the specifications are properly complied with.

By knowledge obtained from his copy of the original order the chief recorder knows what finished form each "heat" of steel is to be made up in, and after it has been rolled in the 28-inch mill into blooms he orders the blooms sent, according to conditions in each case, either to the billet mill to be rolled into finished billets or to the hydraulic shears to be cut into blooms of certain lengths and forwarded from there to anyone of the finishing mills in the plant which rolls the steel into slabs, strip, rod or other form of material.

If the blooms are to go to the billet mill the chief recorder's clerk telautographs to the billet mill's shanty the "heat" or blow number, the size of the billets to be rolled and the proper stamp mark to be used. The billet mill clerk must O-K the message by telautograph before further work on the blooms proceeds. The safe information is sent to the hydraulic shears when the blooms of the "heat" are to be cut up.

In addition to the foregoing the telautographs are employed at the billet mill and at the shears to notify the chief recorder when any breakdown occurs and how long it will take to repair the damage. This permits the chief recorder to plan a redistribution of the work so that no more blooms will be sent to the disabled mill until sufficient time has elapsed for the mill to complete repairs.

Other Telautograph Services in Steel Plants.

According to the geographical layout of the mills the need of various special telautograph services develop in different mills. In some they make good use of a telautograph line between the tube mill and the tube mill shipping office, for the shipping office to report the names, numbers and weights of freight cars they have loaded, together with the net weight of material in the cars. In other plants a telautograph line may be useful between blooming mill and general office for reporting hourly on the progress of the work going through the blooming mill and for answering inquiries made by the general office. Another steel plant uses a line between the blooming mill office and the track sales for reporting net weights of steel loaded on cars.

How the Telautograph Aids the Steel Plant.

On account of the noise existing in a steel plant it is impossible to use the telephone for communication of important messages, particularly those containing figures. Therefore mills have had to resort to the messenger boy for carrying and distributing messages and analyses, and the uncertain quality of a messenger

boy is well known to everyone. The telautograph's introduction into the steel industry replaces this unsatisfactory and dilatory messenger service and in doing so actually reduces the cost as well as increases the speed of distribution.

For instance, in one plant where messengers distributed analyses reports it was costing \$1,200 per annum in wages. They are now using a telautograph system, performing the same function in less than half of the time at a cost of \$480 per annum, showing a direct money saving of \$720, which, after all, is far less than the indirect saving accomplished through the quicker delivery of analyses to the points where the progress of the work is dependent upon them. This is particularly and strikingly true at the open hearth furnace. Before the telautographs were installed, one hour elapsed between the time a sample was taken of the "heat" of steel from the open hearth bath and the time the messenger came back from the laboratory with the analysis. All this time the steel was oxidizing and changing its constituency, and the work of the plant was halted. With the use of telautographs this period of waiting has been reduced to about one-half hour, and, therefore, the melter at the open hearth is able to perform his duties more skillfully and more effectively.

In the blast furnace department the chief gain also is not in money saved through the employment of less labor, but through increased efficiency obtained by getting laboratory reports quicker and thereby enabling the mixers and furnaces to handle their work with intelligence and precision.

In the blooming mill it is impossible to say just how many dollars and cents are saved by the telautograph through the elimination of mixing the "heats" which results in the shipment of wrong quantities of steel to the various customers. It is not possible to estimate how many mistakes would be made and how costly they would be if the telautographs were not used to keep things straight. Very often ingots have been rolled into billets, cut into the required lengths and loaded on flat cars for shipment when it was discovered that the steel had probably been mixed, making it necessary for a chemist to enter the car and drill a sample of every billet for analysis. Also, frequently errors in mixing are not discovered until shipments have been received by a customer and the plant officials are not aware of the fact until they receive the complaint. It has been stated by a superintendent of one mill that the telautographs in this use saves them thousands of dollars yearly. At another blooming mill it was stated that the telautograph service was worth at least \$2,000 a month to the plant.

So it is safe to say that the telautograph is doing its little "bit" in helping the steel industry of this country to perform the tasks thrust upon its shoulders by the needs and requirements of this world-wide war.

Steel Industry Belt Drive Applications

Severe Tests Placed on Belts in Rod Mill, Rolling Mill and Hot Saw Drives — Specifications Given — Necessity of the Proper Care in Operating Belt Drives Emphasized.

By CHARLES A. HIRSCHBERG.

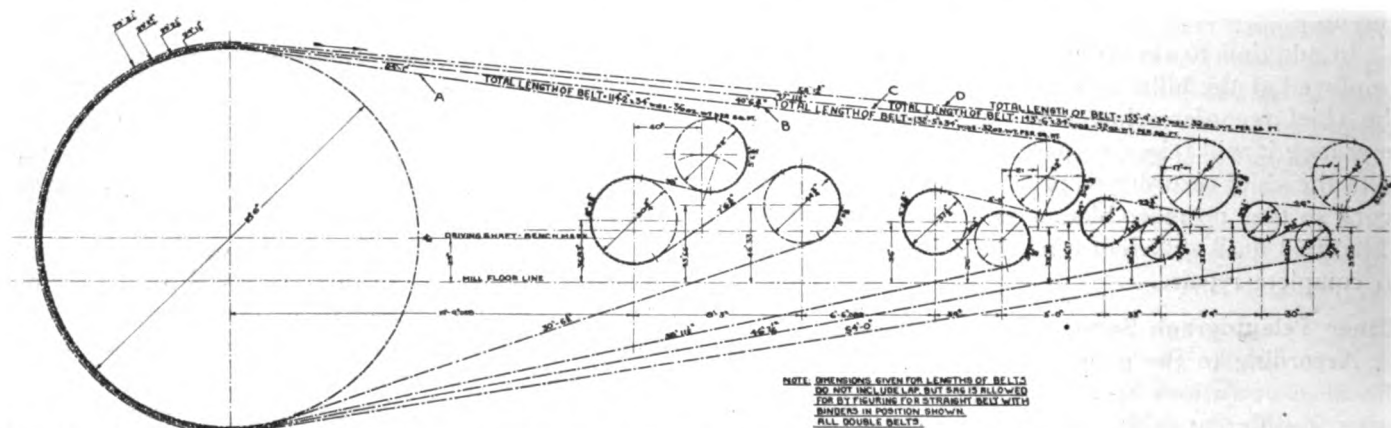
In the steel industry are to be found all the types of belt drives known to other industries. There are a few types of drives which are distinctive of the industry, and are of interest in the problems which they present and which must be overcome in the construction of the belt itself. For instance, in connection with a hot-saw drive, leather belting is put under unusually severe tests. How severe conditions are may be gathered from the fact that the average centers of such a drive range from 10 to 15 feet between pulleys. The belt frequently operating over a pulley of from 6 to 8 feet diameter, being driven by a pulley of but 24 inches diameter. The belt speed ranges between 8,000 to 10,000 feet per minute. While this in itself is severe service, the difficulties of the drive

sion of power by the belt is present; therefore, this slippage and friction must always be taken into consideration when selecting the belt.

The conditions just recited also apply to a great extent in the cold-saw drive. The service is, however, even more severe, because the saw teeth strike with an unavoidable shock against the cold metal in place of molten metal.

In each of these cases the belts vary in width from 10 to 40 inches.

In selecting a belt for this particular type of drive it is essential that care be exercised to purchase it from a manufacturer who has had experience in meeting the problem. It will be found that a chrome or mineral-tanned belt will serve this drive better than



Actual rod mill belt drive, showing four belts running off one pulley, each over the other; that is, each belt rides on a belt, the lower one being the only one in actual contact with the belt face.

are greatly accentuated by the work which the saw is called upon to do. As the saw drives through the hot metal, lubricating oils, containing mineral substances, strike the belt, attacking both the fiber of the leather and the cement at the laps, to say nothing of the intense heat and flying sparks which sear the face of the belt. These trying conditions are made still more difficult by the placing of an idler near the driving pulley for the purpose of obtaining a greater arc of contact to force the belt to transmit a greater amount of power to the driving pulley.

When the saw first strikes the metal, the load on the belt is at the peak point, and the abruptness with which the saw and metal contact occurs causes momentary slippage, tending to blister the belt as well as destroy the tenacity of the cement. No governing device, such as a flywheel, to equalize the transmis-

an oak-tanned belt, due principally to the fact that chrome-tanned leather has a very high tensile strength, and has the necessary pliability to enable it to travel around the pulleys and the idler without breaking the fibers of the stock. It also more readily resists the attack of water and sparks.

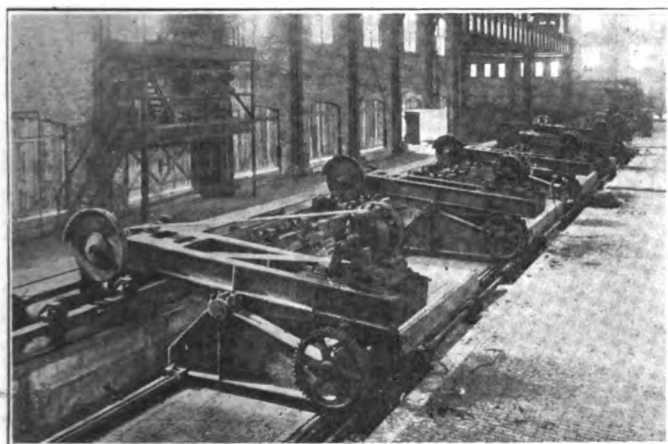
Another extremely difficult drive is that usually found in the rod mill where a belt is called to operate under high tension, the load leaping from no-load to full-load in five seconds. The belts for this class of service frequently range as high as 48 inches wide, running in quadruple formation, usually with three other belts of about 34 inches width, all four belts traveling simultaneously on the same pulley, one above the other.

In a certain Pittsburgh rod mill, the longest belt running under the above conditions is 155 feet 9 inches

long, while the shortest one is 115 feet long. The engine pulley has a diameter of 16 feet, while the driven pulley varies from 18 to 48 inches in diameter. A number of idlers are employed to bend the pulleys; the belt speed is in the neighborhood of a mile and a quarter a minute. This particular drive employs Ladew belts, and the records show that they have now run for four years; a long time for any belt to run in the same position.

To what extent the reliability of the drive depends upon the belt is readily understood when it is noted that if the under belt were to break as a result of defective material or workmanship, it would cause the breakage of the balance of the belts and represent a loss of about \$1,000 per hour in production while the mill was shut down, aside from the value of the belts themselves.

Steel and rolling mill belt drives present unusual difficulties. Some idea can be had from the following Pittsburgh rolling mill specification: A 16-foot drive



42-inch drop hot saws for continuous rail mill, Indiana Steel Company, Gary, Ind.

pulley leading to a driven pulley of 42 inches diameter, the belt is 52 inches wide, four-ply thick, and travels at a belt speed of 4,500 feet per minute. The work consists in forcing steel billets $2\frac{1}{2}$ inches square through six passes, reducing them to a diameter of $\frac{1}{2}$ inch. In this case between 2,500 to 3,000 hp is transmitted. The drive is a straight engine drive with all the steel in the mill at once.

Care of Pulleys.

In a general way it may be said that belts should be kept pliable and full of vitality by the use of the proper amount of belt preservative, using a preservative manufactured from the natural oils originally found in the hides.

It is advisable to place oil catchers around bearings in order to prevent the oils from reaching the

belt. Where possible, bearings should be water cooled.

At least once a week it is advisable to have a competent repairman inspect the belts and see that they are clean and free from attached substances. Laps which show signs of opening should not be pegged down, but should be properly prepared and re-cemented. This usually requires about two hours' time to a belt and does not necessitate the removal of the belt from the pulleys.

Not infrequently, when the points of opening laps have been pegged down, pockets develop, and in two or three days' time the air will force the plies apart, causing a shutdown of the mill for a considerable period of time, or the carrying of a spare belt for use while the injured belt is being repaired.

It is strongly urged that every mill employ an experienced belt repairman. The Edward R. Ladew Company conducts at its Glen Cove, Long Island works, a school for belt makers and is prepared to furnish competent men, or having a capable employee, the writer understands that arrangements can be made with this company for his training in belt making and repairing, free of charge.

Where considerable moisture is encountered it is advisable to employ belting especially built to withstand moisture, such as the Turtleback brand. Such belts are also applicable where the belt speed ranges beyond 4,000 feet per minute. The waterproof cement between the plies and laps, being cold-worked, is not subject to crystallization as a result of the great friction caused by slippage, which is more pronounced at high belt speeds than at low.

A representative of the Ladew company recently related to the writer an interesting story in connection with a rolling mill in the Pittsburgh district. He was called in to prescribe for a belt drive, involving two 3-ply belts; one about 140 feet long and 48 inches wide, the other a rider belt about 147 feet long and 42 inches wide. The position consisted of two pulleys with an idler near the driving pulley. The pull was on the top side of the belt, causing slack at the bottom which was taken up, however, by the rider belt. The belt speed was about 3,500 feet per minute.

The mill's engineers fearing trouble and possible danger at the proposal to place two huge belts running on top of each other, installed steel posts 8 inches in diameter in back of each pulley to prevent the belts from injuring anyone should they fly to pieces. These tandem belts have been racing together for seven years, and the engineers long ago outgrew their timidity.

Acid Open Hearth Steel Investigation

Analysis and Tests from Pit Samples and from the Top, Middle and Bottom Billet Taken from a Forty-Ton Open Hearth Furnace — Tables Showing the Physical Properties.

By T. D. MORGANS and F. ROGERS.

The work described in the present paper was undertaken at the special request of Col. Stansfeld, C. B., deputy director-general of munitions inspection, with a view to determining the general quality and uniformity of the acid open hearth steel made at the Blaenavon Company's works for the manufacture of H. E. shell.

The plan of the investigation consisted in making the following analyses and tests from pit samples and from the top, middle, and bottom billet from one of the 40-ton acid open hearth furnaces.

1. Analyses of pit samples taken immediately before casting each ingot.
2. Analyses of the top, middle, and bottom billet from each ingot.
3. Tensile test from the top, middle, and bottom billet from each ingot.
4. Brinell test from the same.
5. Microscopic examination of the same.

Experimental Cast.

The following are the general particulars of the cast investigated:

Composition of the charge	Tons	Cwts.	Qrs.
Pig iron	19	1	0
Heavy scrap	21	8	0
Shell steel turnings.....	3	0	0
Ferro-manganese	0	11	3
Ferro-silicon (50 per cent silicon)...	0	2	1
Iron ore	2	0	0
Limestone, about	0	14	0
Total	46	17	0

	Hrs.	Min.
Commenced charging	12	50 a.m.
Finished charging	6	0 a.m.
Charge boiling	11	0 a.m.
Charge melted	10	15 a.m.
Tapped	2	10 p.m.

Total time taken for charge, 13 hours 20 minutes. The ferro-manganese and ferro-silicon were put into the bath; none into the ladle.

Analysis of slag taken at the end of the process after the addition of the alloys:

	Per cent
Silica (SiO ₂)	55.67
Alumina (Al ₂ O ₃)	4.11
Oxide of iron (FeO).....	17.63
Lime (CaO)	10.04
Manganese oxide (MnO).....	13.02
Sulphur and phosphorus (S and P).....	traces
Magnesia (MgO)	0.82

Color of slag, bottle-green.

Size of mold.....18½ x 16½ inches (top).

Size of mold.....16½ x 14 inches (bottom).

Top of mold brick lined to the depth of 11 inches.

Abstract of paper read before the British Iron and Steel Institute, September, 1917.

Total length of ingot, 5 feet 6 inches (including head). Ingots teemed in pairs. Approximate weight of ingot, 4,000 pounds. The time taken to teem the whole cast was 25 minutes.

Slag was taken for analysis after the addition of the alloy and after teeming metal into ladle. The bath was caught coming down (no pigging back).

Ore not used after carbon in bath reached 0.70 per cent.

Analyses of Pit Samples.

These figures will be readily appreciated upon reference to the mean, maximum, minimum, and range of variation shown at the foot of the table. The range of variation of carbon is 0.06 per cent; phosphorus, 0.005 per cent; sulphur, 0.009 per cent; manganese, 0.110 per cent; silicon, 0.014 per cent. Practically the irregularities in carbon, phosphorus, and silicon are negligible. The variations of sulphur and manganese are more noticeable, but on reference to the table and the diagram, it will at once be seen that there has been a fairly general fall of sulphur and manganese during the teeming of the ingots, a period of about 20 minutes. The fall of sulphur (0.009 per cent) is much lower, however, in relation to the fall of manganese (0.11 per cent) than would be the case if the removal of manganese sulphide were the sole action.

These results, therefore, give very strong evidence that the fall in manganese is mainly due to the continuance of its deoxidizing action.

The drop in sulphur and manganese in the ladle has occasionally been found by other observers.

Analyses of the Top, Middle, and Bottom Billet of Each Ingot.

The primary feature of the analyses is their regularity. The variation of the sulphur no longer follows a definite fall. This is possibly because the ingot is drawn from a considerable part of the ladle, while naturally the pit sample can only represent a small fraction near to the nozzle at the moment of taking it. The agitation in the ladle during teeming the ingot would possibly be sufficient to mask the tendency evidenced only in the pit samples to removal of MnS.

Manganese in each case appears definitely to fall. The removal of manganese in the ladle may, the authors consider, be taken as distinctly established throughout the present experiments, and this is mainly due to the continuance of its deoxidizing action.

In the bottom bars silicon also appears to have

fallen, but we consider that an explanation founded upon this result might be rather hazardous.

The mean results are assembled in the following table:

	Car- bon	Phos- phorus	Sul- phur	Man- ganese	Sili- con
Mean, top bars....	0.542	0.045	0.058	0.840	0.177
Mean, middle bars.	0.524	0.043	0.055	0.831	0.173
Mean, bottom bars.	0.519	0.039	0.051	0.829	0.167
Range of means...	0.023	0.006	0.007	0.011	0.010
Mean of means....	0.528	0.042	0.055	0.833	0.172
Pit sample means..	0.514	0.042	0.057	0.810	0.175

This shows distinctly the usual slightly higher percentages of elements found in the upper ends of ingots.

The comparison between the means of pit samples and of bar samples shows fair consistency in view of the much superior nature of the general "sample" con-



Section of ingot from sample cast.

stituted by the means from the bars, as compared with the mean pit sample.

It should be noted, as a rough generalization upon the whole of the analyses, that the range of variation in each element is of the order of one-tenth of the amount of the element present (i. e., 5 per cent each way from the mean value), with the exception of silicon in the top and middle bars, which is less than this proportion, and carbon in the bars, which varies only about 3 per cent up and down from the mean. The authors would point out that this degree of variation compares favorably with tests upon single casts which within their experience have been obtained in works practice, and is closer than is usually obtained upon successive similar casts.

Tensile Tests and Hardness Tests.

The tensile and hardness tests, in view of their

practically featureless uniformity, call for very little comment. It is seen that the tests are well up to standards for this class of steel without further heat treatment after rolling to 4-inch square billets.

Tests Upon the Forged Shell.

It has been possible to add some results of tests taken from the walls of the shell which were forged from this cast.

It is seen that these results are well in accordance with the usual specifications for steel of this class; and they show the maintenance of that regularity in quality which was indicated in the more exhaustive tests upon the semi-finished steel already discussed.

Tensile Tests on 4.5-inch Shell Forgings.

Elastic limit, tons per sq. in.	Maximum stress, tons per sq. in.	Elongation per cent on 2 in.
Over 19	48.1	21.6
Over 19	47.6	21.6

Section of Ingot.

Fig. 1 shows a photograph of a section of an ingot from another cast, A20, the particulars of whose manufacture are practically identical with those given on pages 1 and 2 for the experimental cast, all of the ingots of which were rolled into billets. This ingot was teemed in $2\frac{1}{2}$ minutes. Its weight was 1 ton 18 cwt. 0 qr. 18 lb.; and the weight of top discard was 4 cwt. 2 qr. 20 lb., which is 12.26 per cent of the total weight of the ingot. The following is the chemical analysis of this ingot:

Carbon per cent	Silicon per cent	Sulphur per cent	Phos- phorus per cent	Man- ganese per cent
0.44	0.164	0.050	0.045	0.820

The tensile test from the same cast rolled to 4-inch billets was:

Elastic limit, tons per sq. in.	Maximum stress, tons per sq. in.	Elongation per cent on 2 in.
21.9	43.4	22

The illustration will show that the pipe is very satisfactorily located in the head, and its form indicates no tendency to secondary pipe.

Microstructure.

Photomicrographs were taken under comparative conditions from 17 of the billets at random. The position of the field photographed was in every case approximately upon the continuation of the axis of the tensile testpiece, and near one corner of the section of the billet, about $\frac{1}{2}$ -inch from each of the neighboring sides. The magnification was 50 diameters.

Three photomicrographs at a higher magnification (500 diameters) show in greater detail the nature of the structure in the same positions.

The structure consists of a ferrite network, which is partially discontinuous in places, whose meshes are filled with generally lamellar pearlite. Towards the edges of the billet the network size is smaller, and towards the center larger than at the field adopted as standard for the photomicrographs.

Blast Furnace Slag Viscosity Tables

Discussion of Paper Read Before A. I. M. E., by A. L. Feild
and P. H. Royster, Which Appeared in the March Issue
of The Blast Furnace and Steel Plant.

D. J. Demorest*.—This paper is a real contribution to technical science; it will make it easier to think accurately about the inner workings of a blast furnace. I was rather surprised to read that the authors regarded as a new discovery the idea that a molten mixture of CaO , Al_2O_3 , and SiO_2 is a molten solution of the compounds of these oxides rather than of the oxides in each other. Surely no chemist with an active respect for the known facts of chemical affinity could believe that these oxides could be melted together without forming compounds, and that these compounds would then dissolve in one another. This work does, however, help to establish what it was supposed must be true.

I think it is worth while, in the light of the work of the Geophysics Laboratory, this work of the Bureau of Mines, and that of previous investigators, to visualize what happens as a charge passes down through a blast furnace, thinking especially of the slag-forming materials. These are chiefly kaolin ($\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot 2\text{H}_2\text{O}$), quartz, and limestone. These substances do not undergo much change until the limestone decomposes at about the middle of the furnace, whereupon the chemical affinities of CaO and SiO_2 must begin to be active, especially if there is any amorphous SiO_2 present. This forms CaSiO_3 , and the SiO_2 , CaSiO_2 and $\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2$ then come together to form the binary and ternary eutectics so well located by the work of the Geophysics Laboratory. No matter how much lime has been charged into the furnace, the formation of this eutectic will start at about the same height in the furnace and the gangue will start to get pasty at the same height. If the charge is such that the gangue materials are in proper proportion to be entirely consumed in making this eutectic the slag will be completely liquid high in the furnace, will soon become superheated, and will run rapidly through the furnace.

This will mean, of course, that the slag will not remain long enough in contact with the coke and reduced iron to remove the sulphur from the iron or to permit the silicon to be reduced. Its time of contact will be short and its temperature will be low. If, however, there is an excess of lime over that required to form the eutectic, only this lime will dissolve in the eutectic, make it viscous, and keep it viscous as long as there is lime left to go into solution. It will, therefore, not become free-running until it has gone further down the furnace than the first

slag. The more lime present, the longer it takes to dissolve it (I am referring to ordinary coke practice which requires a basic slag), the longer the sticky slag stays in contact with the iron and coke, the hotter it gets, and the longer the time afforded to reduce silicon and remove sulphur. The upper limit will, of course, be a mixture containing more lime than the slag will dissolve; whereupon the furnace "limes up." There is, of course, nothing new in this. It was very clearly set forth in Howe's "Iron, Steel, and Other Alloys." I have none of my notes or books here and cannot write accurately, but I think that these "Viscosity Tables" will correspond well with the triaxial diagram worked out by the Geophysics Laboratory.

F. H. Willcox†.—Until about six years ago, one of most striking tendencies in American blast furnace practice was the use of large amounts of lime. This has, in the past, undoubtedly been carried to an extreme. The difficulties encountered in such practice have, perhaps, overemphasized, in some cases, the significance that may be attached to slag characteristics as a corollary of furnace economy and regularity.

Eleven years ago, when many furnaces in the Pittsburgh district were running decidedly limy, the real reason that they were doing so may have been the fact that the relatively rich ores were actually deficient in slag-making constituents. Gravel was often regularly added to the burden in order to give a volume of slag that would eliminate sulphur satisfactorily. The ores were frequently deficient in aluminous constituents, and some intangible requisite being lacking in the slag, lime was made to do the duty of the missing alumina. It apparently required an inordinately large amount of limestone to do the work that could be done by a considerably less proportion of alumina.

In this same district, plants that then used to run on a total acids of 46 to 47 per cent, with alumina at 13 to 14 per cent, are now running on total acids of 51 to 53 per cent, with alumina of 17 to 21 per cent, and the work is very much smoother.

Coinciding with the changes in slag, improvements have been made in lines and distribution. Nevertheless it is the opinion of some operators that replacement of limestone by clayey and feldspathic gangue in the ore has been of material benefit in their practice.

While Pittsburgh, in these earlier years, was get-

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† Secretary, Freyn & Co.

ting the richer ores, to avoid the freight haul on the higher gangue ores, the lake ports were taking a higher proportion of the leaner ore. It was at these lake port furnaces that the use of sharp cinder on basic iron first became established practice. This resulted from the fact that the ores contained an adequate amount and variety of gangue components, just as a limy cinder in the Pittsburgh district followed from the consumption of rich ores. Similar mention might be made of the conditions of furnace practice where slags unduly rich in magnesia or alumina have been carried.

I have made mention of these instances for three reasons: (1) I believe that the character of the cinder made in any given furnace district is very largely governed by geographical situation, and by a variety of relations in the purchase of ore, coke, and limestone such as inter-company associations, traffic conditions, competitive prices, etc., with little attention to the metallurgical significance of the resulting slag. (2) I believe that aside from extremes in basicity, magnesia, or alumina contents, there is a very considerable range over which normal economical practice is obtained. (3) It is my impression that the occasional emphasis placed upon slag constitution, as governing to a marked degree the smoothness of furnace operation, is founded on experience with slag

unduly rich in bases, magnesia, or alumina, rather than upon definite data with widely divergent slags afforded by normal practice in the several districts.

Prior to this investigation, there was a smaller amount of exact scientific knowledge of this subject—the constitution and viscosity of fluid blast furnace slags and their effect upon furnace practice—than upon any subject connected with blast furnace work. The paper is valuable in that it helps to remove another element of uncertainty from the problems encountered in practice.

The blast furnace process is still perhaps the most sensitive and the most crude of large-scale manufactures. The chemist, metallurgist, physicist, and engineer have done much toward removing uncertainties in recognizing and treating symptoms, and in eliminating their causes. Efficient stoves, correct lines, good distribution, stronger construction and adequate machinery have largely contributed to past developments, together with the accumulated experience of furnace men in adapting their practice and equipment to leaner ores and changing fuels.

Contributions which advance our knowledge as to the fundamental physical-chemical laws of blast furnace metallurgy are strongly to be encouraged, and it is to be hoped that the Bureau of Mines will continue to follow investigations in this field.

The Microscope to Detect Steel Impurities

An Explanation of Methods of Detecting and Identifying the Various Non-Metallic Impurities Occurring in Basic Open Hearth and Electric Steels.

By JOHN McCONNELL.

By the aid of the microscope we can determine the uniformity of the metal; we can determine any segregation or piping, and if there is any segregation we can determine the impurities causing this segregation; we can estimate closely as to the amounts of these impurities and with experience can tell to what degree they will be harmful. It is also possible to definitely determine if steel has been rolled from seamy billets or blooms or whether the apparent seams in the finished bar are not due to some other cause. We might mention here that the error is frequently made of attributing any and all cracks in a rolled bar to seamy billets. By chemical analysis we can determine the amounts of the various oxides, silicates, sulphides and phosphides; but we can only get a general idea of their distribution and these analyses are at best very laborious and often lead to inconclusive if not misleading results. One of the greatest factors in the harmful effects non-metallic impurities may have on steel is their distribution, and this point will not in general be revealed by the chemical analysis.

The microscope seems to be the logical method to obtain the desired result; i. e., a rapid, reasonably accurate estimate of the kinds, amounts and distribution of the non-metallic impurities. The section is examined for non-metallics before etching as the non-metallics show up better against the polished metallic background than they would after etching and the section had been discolored.

Just how these impurities come to be in the steel is a much disputed question, but at this time no effort will be made to go into the matter in detail. It might be of interest, however, to mention some of the ideas held on this point. Various ideas as to the cause of their presence are that they are:

1—Formed and held in the metal during the process of manufacture.

2—Formed and held in the metal after the addition of deoxidizers, recarburizers or ferro alloys.

3—Caused by oxidation as the molten metal passes through the air in pouring.

4—Caused by pieces of lining of furnace and ladles passing into the metal.

I am of the opinion that if in the process of manufacture the proper slag has been produced, if time is given for this slag to collect the non-metallics distributed through the bath of metal, if the casting conditions are such as to minimize segregation other than the pipe, there will be a minimum of non-metallics in the finished steel. In other words, if the steel is "clean" on tapping and the casting practice is O. K., we can expect a finished product that is "clean."

We will first give a list of the non-metallic impurities which may occur in basic open hearth or electric alloy steels and then discuss each one in detail.

1—Slag. Under this head we will include the oxides and silicates of both iron and manganese.

2—Manganese sulphide (MnS).

3—Iron sulphide (FeS).

4—Phosphorus (forms Fe_3P which forms a solid solution with ferrite).

5—Alumina (Oxide of aluminum Al_2O_3).

6—Oxide of chrome (Cr_2O_3).

7—Gas inclusions (N-H-CO).

1—Slag. 2—Manganese Sulphide.

On account of the general similarity of appearance and association we will discuss the above two impurities together. The reader will note that under the heading slag we are including:

a—Oxide of iron.

b—Oxide of manganese.

c—Silicate of iron.

d—Silicate of manganese.

After solidification of the metal the connection between the slag or MnS and the steel is simply mechanical. These appear as particles imbedded in the matrix of steel, their shape depending on the amount and kind of work given the steel. In castings they appear as rounded globules, in rolled or forged bars as elongated globules. The amount of elongation of the globules depends on the amount of reduction in the rolling or forging. In a large round the elongation will be slight, while in a small section (flats in particular) these impurities will be present as long thin threads.

In regard to distinguishing between slag and MnS particles, we will say that three properties should be examined, viz.: color, condition of the edges, and appearance after boiling in a solution of sodium picrate. MnS will appear as a light dove gray, while slag will be darker, approaching a slaty blue. MnS is plastic at a rolling heat and is readily elongated in rolling or forging and the edges appear smooth. Slag is not as plastic and is brittle, and the edges are torn and appear relatively rough, due to the rolling or forging operations. On boiling a specimen containing MnS and slag in a solution of alkaline sodium picrate for about 10 minutes the MnS will be attacked. We are greatly indebted to Mr. Comstock for his valuable paper in "The Iron Age," December 14, 1916. In this paper the details of the test for the distinguishing between MnS and slag are given. We will briefly

say here that very often it is quite difficult to be positive as to the non-metallic impurity being slag or MnS . Mr. Comstock's test is to boil the specimen about 10 minutes in a solution of alkaline sodium picrate, the solution acting on the sulphide but not on the slag. Hence, an examination of our specimen after boiling will show black pits (where the impurity was), if the impurity was sulphide, or will show the same as it did on the original examination if the impurity is slag. We will say that we are using this test and find it to give very excellent results.

Unfortunately there is not at present any practical microscope method for a steel works laboratory to distinguish between the oxides or silicates of either iron or manganese, so we are only able to classify our impurities of this type as either MnS or slag. This is especially troublesome in a bar which is cracked, and we find this crack under the microscope to be filled with a slaty blue impurity which shows the color and other tests of slag. But can we be sure it is slag? We know that scale is oxide of iron, and when polished and examined under the microscope, shows the color and other tests of slag. In a case of this nature, we must resort to indirect methods to determine if the crack was caused by a slag segregation which has opened up or is to some other cause, and some later heating has caused the edges of this crack to become scaled. If we have produced a scale we will find some decarburization at the edges of the crack next to the scale. If we have a segregation of slag, there is bound to be some MnS with this slag, and if on boiling in sodium picrate we are able to prove the presence of MnS , it is safe to assume our blue impurity is slag and not scale. It is by this and other indirect lines of reasoning that we have to resort for our indication of slags and scales. It is to be hoped that methods will soon be found that will lead to positive identification of scale and the various constituents in the slag.

When any impure liquid mixture freezes, the first part to crystallize will be the pure substance; this will continue freezing and the remaining liquid will become more impure as the pure substance crystallizes, since the amount of impurity is the same and the amount of liquid is decreasing, due to the freezing of the pure substance. This will continue until the very impure liquid is frozen.

This is exactly what takes place in the freezing of an ingot of steel. The pure steel starts to freeze on the walls of the mold. This goes on and whatever impurities that are in the steel on casting, such as slag, MnS , Al_2O_3 , Cr_2O_3 , Fe_3P , etc., remain in the liquid, making it richer and richer in impurities until it finally freezes. This will, of course, go on in a great many parts of the ingot and will cause spots of very pure and also very impure steel.

On rolling these impure spots will be elongated and may appear as bands, ghosts or segregations, as

they contain most of the impurities which go to form these.

The longer the metal takes to freeze the more chance these impurities will have to collect to form impure spots, because the quicker the ingot can be frozen the more evenly distributed will be all these impurities, and the more evenly they are distributed the less will be their harmful effect.

Hence, the following conditions are best to lessen banding or segregation:

- 1—Narrow ingots.
- 2—Cool, thick-walled molds.
- 3—Low casting temperature.
- 4—Quiet casting.
- 5—Early stripping.

3—Iron Sulphide (FeS).

Sulphide has the property of combining with both manganese and iron to form MnS and FeS. It will, however, unite with the manganese first and if there is sufficient manganese present, all the sulphur will form MnS. If, however, there is not sufficient manganese present, or the manganese is not well mixed into the steel and brought in contact with the sulphur, what sulphur that does not form MnS will form FeS. This FeS appears under the microscope as yellow or pale brown spots and if present in any amount will appear as an envelope around the crystals. MnS is together the FeS gives the MnS a yellowish tint. FeS usually associated with FeS, and when they appear can also be determined by Mr. Comstock's test as the alkaline sodium picrate acts on the FeS the same as it does on MnS.

The reason that FeS in steel causes hot shortness is because of its slow melting point. FeS melts at a temperature below a rolling temperature and so the FeS is in a molten condition at a rolling heat, and there is no cohesion between crystals surrounded by this FeS and the steel crumbles on rolling.

The cold shortness is caused by the brittleness of the FeS which, as explained above, occurs as envelopes around the crystals.

4—Phosphorus.

Phosphorus does not occur in the pure form in steel but combines with the iron to form a chemical compound (three parts of iron and one of phosphorus, Fe_3P). This Fe_3P dissolves in the remaining iron (ferrite) exactly the same as salt dissolves in water; the salt in water is spoken of as a liquid solution, while the Fe_3P dissolved in iron is called a solid solution. It is impossible to see this solid solution of Fe_3P in ferrite in a polished section unless the section has been treated in some way to bring it out. Such a treatment has been worked out.

The polished section is immersed in a solution of copper. Copper will not deposit on any part of the steel which contains an appreciable amount of phosphorus; it will, however, deposit very readily on parts of the steel which contain very little phosphorus.

After treating the section with the copper solution it is examined, and parts rich in phosphorus will not have any copper deposited on them, while the parts which are more pure will have the deposit of copper.

In this way we can see if the phosphorus is evenly distributed. Phosphorus is said to be about the worst thing to segregate in steel, and we have noted that every time a segregation of anything in the steel has been found, we have been able to find segregation of phosphorus by the above method.

This is especially true of banding in steel. The bands seem to be due to parts of the ingot being rich in phosphorus; on rolling, these parts are elongated into bands. The rolling is finished at a temperature above the critical range, hence the carbon is dissolved; on cooling on the hot beds the carbon comes out of solution and ordinarily would be evenly distributed through the bar. A segregation of phosphorus tends to expel or prevent any carbon from depositing on it, hence the carbon will appear segregated between the bands of the ferrite which contain the phosphorus.

5—Alumina.

Aluminum does not exist in steel as the metal, if it can find any oxygen to combine with to form the oxide (Al_2O_3) called alumina. This oxide shows under the microscope as round black spots; the individual spots are never elongated, but they usually occur in quite a large number making up a group, and the group as a whole is elongated in the direction of rolling. Alumina is very infusible, has practically no strength, and is very harmful if present in steel in any amount. Alumina should only be used in the ladle and not in the mold.

6—Oxide of Chrome.

Chrome forms the oxide (Cr_2O_3) and shows under the microscope as small angular crystals of a purplish color.

7—Gas Inclusions.

No methods have as yet been found to detect the presence of included gases in steel by microscopic methods.

This paper, dealing with the impurities and application of the microscope in their detection, has been written with the idea of placing before the practical steel man a few of the uses and possibilities of the microscope in the hope of stimulating its use among steel manufacturers.

This paper is not meant to give a technical explanation of the occurrence and identification of non-metallics in steel, but rather an explanation which can be understood by one who has not made any special study as to the microscope and its application.

The writer wishes to express his thanks to Messrs. J. W. Alden and M. H. Schmid, of the metallurgical department of the United Alloy Steel Corporation, for their cooperation in the preparation of this paper.

PRODUCTION TOPICS

THE COST IN COAL OF AVOIDABLE BELT SLIP.

Avoidable losses are the ones to stop, always, especially if they can be stopped at small expense.

Never before have we understood the strategic and money value of coal as thoroughly as we do now. Never before has it been so necessary for us to save, even though considerable money must be spent in order to effect the saving.

One of the very simplest losses to overcome, however, and at small expense, is belt slip, and since belts are used to so great an extent it will pay to look into the matter with more thoroughness than has been given it in the past. To

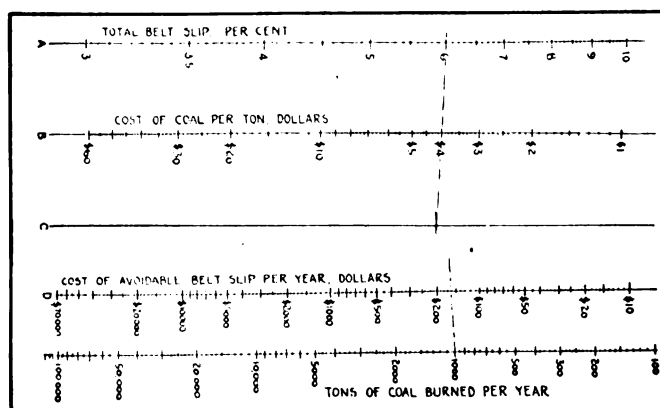


Chart showing power losses caused by loose belts.

show the extent of the loss of money through slipping of the main belt alone a chart, supplied us through the courtesy of the Cling-Surface Company, Buffalo, N. Y., is shown here-with, upon which this is easily ascertained. By glancing up and down column "D" of this chart it is evident that the "cost of avoidable belt slip per year in dollars" may vary all the way from the smallest sums into the thousands of dollars.

Where the power in the first place is generated by a steam engine and is then transmitted to a generator, or to the main shaft through a main belt, it is evident that the "entire coal pile" passes through that in the form of energy, literally speaking. If the belt slips, which it should not do, a certain portion of the coal pile does not "get through" but is lost into the atmosphere in the form of waste heat. A main belt is merely a "link" connecting the engine with the generator or with the machines themselves. In fact, every belt that transmits power is a connecting link and the efficiency of that link depends largely upon the freedom from slippage and the avoidance of strain on the shafts. Slipless, easy-running belts are most desirable.

A Power Plant is a Train of Links.

For the moment it might be well to dwell upon this thought, as it is seldom looked at in just this light.

We have for the first link the coal on the grates which only perfect combustion can turn into maximum heat; next the boiler shell and tubes—they must be clean to bring the heat link to the steam link; next the steam line from boiler to engine or turbine—large enough and well insulated; then the engine or turbine link which joins heat energy and mechanical energy—only careful design, proper valve setting and much care minimize losses here.

Then, where power is distributed solely through belts and

pulleys the belts, pulleys, and shafts or electrical cables to the final motors and belts are the connecting links up to the very machines themselves.

If the efficiency of every link is maintained at its highest point the power end of the plant is beyond criticism. The overall efficiency will then be very high. But if the efficiency of every link is low or indifferent the overall efficiency of the power end will be distressingly low.

Mere Matter of Detail.

Many of us talk glibly about efficiency as though it could be acquired over night. Thus one man has stated that "efficiency is a mere matter of detail." His definition is all right, but detail is not a "mere matter."

Belt Slip is Not a "Mere Matter" Either.

For these various reasons, therefore, it is plain that power transmission through belting is a "detail" on which we should "plug" until all avoidable slip is eliminated. It is especially important, as stated before, where all the power passes through a single main-drive belt. Each per cent of slip in such a belt represents a loss of 1 per cent of the coal pile.

Roughly, 2 per cent of the potential power in the driving pulley of the engine is represented by "belt creep." Its loss is unavoidable because of the elasticity of the belt. This has been recognized and provided for in the chart, so the reader can go ahead and connect known values, while the intersection with column "D" gives the avoidable money loss.

Simply zig-zag across the chart twice with a straightedge, as shown by the dotted lines, and the money loss is immediately found. Thus, if the total belt slip is 6 per cent (column A) and the cost of coal per ton is \$4 (column B), run a straight line through those two points and locate the intersection with column "C." Then from that point of intersection run over to the tons of coal burned per year (which in this instance has been stated as 1,000 tons) and the cost of avoidable belt slip per year is shown by column "D" as being \$160.

For \$160, as the makers say, one can purchase a great deal of cling-surface, and one can in consequence well afford to give a little time every month to the care of the belting. Yearly loss due to belt slip is often considerably greater than \$160, for it must be remembered that this chart applies only to one belt—the main belt. If all of the distributing or secondary belts slip equally as much the yearly loss is double, triple, or even four times as much as \$160.

To give a clear idea as to the meaning of "total belt slip per cent," let us take an example. You find by means of a revolving counter that a given driven pulley is rotating only 940 times per minute. You figure that without slip it should rotate 1,000 times per minute; 60 revolutions per minute, therefore, are absolutely lost. Dividing this 60 by the r.p.m. that pulley should make you get 0.060 or 6 per cent, which is the "total belt slip." After having made this determination, now it is a simple matter to apply it to the chart as has been done and determine the money loss per year due to such slip.

Furthermore, belts which do not slip do not require tension and can be run easy or slack—every belt thus relieved of its tension reduces by that much the total plant friction load and this means also a longer-lived belt, cool bearings, less oil used, less time of men and machines lost during repairs and more power at the machines; for friction represents lost power.

PRODUCTION TOPICS

SPINEL IN BLAST FURNACE SLAGS.

By A. MARSHALL LeTELLIER.

Noting an article in the April issue of THE BLAST FURNACE AND STEEL PLANT entitled "Alumina Influence in Blast Furnace Slags," by C. R. Jones, the writer feels that it would be of interest to chemists and blast furnace managers as well to further discuss the subject and explain what the impurities are which sometimes occur in the silica portion of a slag treated by the hydrochloric acid method and also offer further explanations regarding the conditions favoring the formation of this impurity in blast furnace slags.

This impurity occurring with the silica from the slag is a definite compound of magnesium and aluminum, commonly called spinel, and known to the chemist as magnesium aluminate, having the formula $Mg(AlO_2)_2$. This compound or substance theoretically contains 28.29 per cent magnesia and 71.71 per cent alumina and by actual analysis covering months of blast furnace practice the substance was found to always occur in this proportion. The chemist can readily see the saving of time in the routine analysis of slags by volatilizing the silica with hydrofluoric acid and calculating the percentage of the magnesia and alumina in the residue without further analysis.

As to the conditions favoring the formation of spinel in blast furnace slags there are three governing conditions as follows: The magnesia content must be over 10 per cent, the alumina content must be over 12 per cent and the silica content must be not more than 33 per cent.

The first two conditions have in previous articles been very ably discussed so it is the last condition which will bear special mention. Regardless of the alumina and magnesia content of a slag, spinel will not form in a "lean" or acid slag; the analysis below taken from actual routine analysis prove this interesting fact.

	Silica	Alumina	Magnesia	Spinel
Analysis No. 1.....	34.16%	15.10%	14.08%	none
Analysis No. 2.....	33.68%	14.77%	15.41%	trace
Analysis No. 3.....	32.00%	14.81%	14.67%	.70%
Analysis No. 4.....	30.30%	15.09%	14.86%	2.40%
Analysis No. 5.....	29.16%	14.93%	15.06%	5.03%

The explanation seems to be that when there is an insufficient amount of silica to combine with the lime and magnesia, which means a basic slag, that a part of the magnesia combines with the alumina in place of the silica, forming the very insoluble and inactive compound of spinel, which is often reported by the chemist as silica.

EDITOR'S NOTE—The author of the above contribution is chief chemist of the Wickwire Steel Company. With further reference to the same article the following comment is also made by Edward C. Jones, chemist, Lavino Furnace Company, Marietta, Pa.:

In late publications I have noticed articles with reference to trouble in completely dissolving certain blast furnace slags in hydrochloric acid. The slag from the furnace at which I am employed is of this nature.

I have recently found that if such slags be granulated, this compound that makes the slag insoluble (spinel) is changed so that it becomes soluble in hydrochloric acid.

The practice of pouring into a bucket of water an equal amount of each flush of slag for the 24 hours is employed. This sample is mixed, quartered to small bulk, spread out on a sheet of metal and placed upon a hot cast of ferro-manganese or one of the blow pipes of the furnace to dry. The

sample is now in a state for the chemist to make a rapid determination of silica, alumina and manganese.

Since the slag has this treatment I find it unnecessary to further treat the insoluble matter after the hydrochloric acid treatment, as the insoluble matter is practically pure silica and practically all alumina is in my filtrate.

MOTOR SUCCESSFULLY REPLACES STEAM ENGINE

A striking example of the successful replacement of a steam engine by an electric motor is furnished by the installation in the plant of the Cleveland Hardware Company, Cleveland, O. This company manufactures drop forgings for automobiles and similar classes of service.

For a period of 35 years the company has been operating a 9-inch merchant rolling mill belted to a steam engine which by this time had outlived its usefulness, and it was necessary to install a new drive, as the breakdowns were becoming frequent. The company was forced to consider a new driving unit. After a careful investigation of the subject, the unanimous decision was that an electric motor was the only logical solution of the problem, the wisdom of which has been more than justified by the entire absence of any trouble since the installation and an economy of operation better than was anticipated.

A feature of particular interest in connection with this installation is the purchase of electric power for the operation of the mill from the local lighting plant, the Cleveland Electric Illuminating Company, at a price which is far more reasonable than could be obtained by means of a privately-owned plant.

Since the installation of electric drive, there has been a very noticeable increase in production by the mill, due to the constant even speed obtained from the motor.

Possibly the most striking feature of the equipment is its simplicity. The motor was placed close to and connected by gears to the rolls, and this with the transformers and control, constitutes all the apparatus necessary.

Current is obtained from the illumination company at 11,000 volts, 60-cycles, three-phase, and is stepped down by means of a three-phase, oil-insulated, self-cooling transformer to that for which the motor is wound, namely, 2,200 volts.

The motor is of the Westinghouse wound-rotor type, with a rating of 450 hp at 900 r.p.m. and 360 hp at 720 r.p.m. These synchronous speeds are obtained through a double winding designed to give the motor either 8 or 10 poles, according to the speed desired.

The synchronous speeds of the motor are reduced to speeds of the mill shaft of 240 and 192 revolutions per minute, respectively, by means of a herringbone type gear drive, which operates in oil in a completely enclosed case.

The motor shaft is connected to the pinion by means of a Nuttall spring type, flexible coupling, especially designed for steel mill service.

A similar coupling connects the gear to a 10-ton, open hearth steel flywheel, 12 feet in diameter, which is mounted on two extra heavy pillow blocks, the other end being connected to the rolling mill. The wheel is made in one piece with rectangular arms.

The control of the equipment is handled by a two-panel block enamel switchboard, mounted on angle frame iron framework.

The switches for changing the windings on the motor from 8 to 10 poles are oil-immersed; one in the primary and

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one in the secondary circuit. Proper markings are placed thereon so the mill operator can easily manipulate them. The primary breakers are mechanically interlocked so, but one can be closed at anyone time.

In case it is necessary to stop the mill quickly, as in an emergency, the running breaker is tripped, which causes all the secondary breakers to open. The operator then closes the reverse breaker, which quickly brings the motor to rest.

The operation has been an entire success from its beginning and, in the opinion of the officials of the company, electric drive is the most desirable form of motive power to be considered for rolling mills.

An idea of the work being done by the mill may be gained from the following figures:

In an average eight-hour shift, the average tonnage of $\frac{3}{8}$ -inch rounds from 4 x 4-inch billets, 90 to 100 pounds weight, 25 per cent carbon, is 35 tons; $\frac{7}{8}$ -inch squares, 45 tons; $1\frac{3}{4}$ x $\frac{1}{4}$ -inch flats, 40 tons; 100 to 135, 4 x $\frac{5}{16}$ -inch flats, 35 tons; and 2 x 3, 40 pounds, 15 per cent carbon, $\frac{3}{4}$ x $\frac{1}{8}$ -inch flats, 15 tons; 50 pounds, $\frac{3}{4}$ x $\frac{3}{16}$ -inch flats, 20 tons; 40 pounds, $\frac{3}{8}$ -inch round, 20 tons; 55 pounds, $\frac{1}{2}$ x $\frac{5}{16}$ -inch, ovals, 30 tons.

The entire electrical equipment was furnished and installed by the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

Howard R. Taylor is the mechanical engineer of the Cleveland Hardware Company, and was responsible for the change over from steam to electric drive which has worked out to his entire satisfaction.

CALIFORNIA MAGNESITE.

Owing to the war, the supply of Austrian magnesite was cut off, and another supply had to be found. The California magnesite replaced a good deal of the Austrian, but owing to the high prices quite a number of steel plants turned to dolomite as a substitute for magnesite.

It was at first thought that California magnesite would not prove as good a magnesite as the Austrian, but it has been found that by adding iron in the right proportion, California magnesite is even better than the Austrian. Some steel plants prefer to use the so-called ferro magnesite, that is, magnesite to which iron has been added, mixed thoroughly and which has then been clinkered. Others prefer to use the so-called dead-burned magnesite and add their own iron at their plant.

Magnesite, while a little more expensive per ton, owing to its durability, is much cheaper in the long run, inasmuch as it only has to be replaced once in 30 to 40 days and consequently does not interfere with production the way its substitutes do.

HEATING OF COAL IN PILES.

By C. M. Young.*

Bituminous coal piled in heaps or bins frequently undergoes a process of spontaneous heating as the result of the absorption of the oxygen. It seems probable that the first absorption of oxygen by coal which has not previously been exposed to the air may occur as a condensation or a combination of oxygen in some form which does not result in the production of carbon dioxide. The absorption of oxygen is accompanied by an increase of temperature, and this by an

increased rapidity of absorption; hence the dangerous condition proceeds from bad to worse, until the kindling point is reached, unless the process is interrupted.

A dangerous rise of temperature can be prevented by excluding oxygen, by increasing the bulk of coal in proportion to its surface exposed, or by circulating enough air to dissipate the heat produced. The storage of coal, in practice, varies from almost complete exclusion of oxygen, by storing under water, to such freedom of access as exists when the coal is stored in open piles.

Oxygen available for absorption by coal is supplied by the air in the interstices between lumps and by additional air which may enter the pile through circulation. The size of the coal largely affects both of these supplies; for if the lumps are small the spaces between them constitute a small percentage of the total volume, and little oxygen will be available unless the circulation of air brings in a fresh supply, while with large lumps the percentage is relatively large; circulation also is much easier through a pile of coarse lumps. In the case of lump coal, although a large amount of air may be present, the exposed surface is comparatively small and there is little opportunity for the absorption of oxygen to be so rapid as to cause dangerous heating. Attempts have been made to prevent heating by allowing a sufficient circulation of air to carry off the heat generated; obviously this method cannot be applied to fine sizes nor mixed sizes.

When storing coal at the University of Illinois, an attempt has been made to use so much fine coal and to pack it so thoroughly as to prevent circulation of air, while also reducing the original air in the pile so as to prevent heating. This method has been fairly successful, but in some cases the piles have heated. An investigation made when a pile was opened for the removal of portions which had begun to heat indicated that heating had occurred only in those parts of the pile which contained comparatively small proportions of fine coal.

To confirm the impression given by the appearance of the pile, samples of coal were taken from the spots where heating was evident, and from neighboring regions in which there was no evidence of heating. These samples were then sized on screens ranging from 2 to $\frac{1}{8}$ -inch round hole, giving the following results:

Size	Heated region		Unheated region	
	Percent	Cum. Percent	Percent	Cum. Percent
Over 2 inch.....	0.0		0.0	
1 to 2 inch.....	32.6	32.6	6.3	6.3
$\frac{1}{2}$ to 1 inch.....	36.4	69.0	22.9	29.2
$\frac{1}{4}$ to $\frac{1}{2}$ inch.....	12.2	81.2	24.8	54.0
$\frac{1}{8}$ to $\frac{1}{4}$ inch.....	7.4	88.6	18.5	72.5
Below $\frac{1}{8}$ inch.....	11.4	100.0	27.5	100.0
	100.0		100.0	

It appears from this examination that the portions of the pile in which fine sizes were present in largest proportion did not contain sufficient oxygen to heat the coal to any noticeable extent. The close packing had also so obstructed circulation that little fresh oxygen could have been brought in even if the temperature had been raised to such an extent as to favor circulation of air. This indicates that one comparatively safe way to store coal is to use enough of the fine sizes to occupy the space as completely as possible, and to pack the coal tightly in order that the air space may be reduced and the circulation of air restricted.

* Paper read before A. I. M. E., New York, February, 1918.

NEWS OF THE PLANTS

BY-PRODUCT COKE PLANT.

The Indiana Coke & Gas Company, of Terre Haute, Ind., will make an extension to the present by-product coke plant. They have contracted with H. Koppers Company, of Pittsburgh, Pa., for the erection of 15 Koppers ovens with the necessary additions and changes in the present equipment to accommodate this increase in the plant. The present plant consists of a battery of 30 ovens. The new addition of 15 ovens is so arranged that a second addition of 15 ovens can readily be installed. The present plant, with the addition of 15 Koppers ovens, will have a capacity of approximately 800 tons of coal per day.

The surplus gas from this plant is distributed in the city of Terre Haute for domestic purposes. The coke produced by this plant is sold for domestic and metallurgical use.

SYDNEY, N. S., STEEL PLANT.

Construction of a plant for the rolling of steel plates, angles, etc., to meet the demands of the shipyards of Canada for some years, will commence at Sydney, N. S., soon. Arrangements were made between Hon. C. C. Ballantyne, minister of marine and fisheries, and the Dominion Iron & Steel Corporation. The company will build a plant capable of producing 150,000 tons of ship steel annually and will receive orders for its product from the Canadian government, and will also be free to fill private commercial orders. The plant will entail an expenditure by the Dominion Iron & Steel Corporation of from \$3,000,000 to \$5,000,000, and will be ready for operation in about a year and a half.

PIG TIN SHIPMENTS FROM THE PACIFIC COAST.

A letter has been received from A. G. Young, chairman sub-committee on traffic conditions, American Iron and Steel Institute, which is quoted in full for the information of the trade, as follows:

"The greater part of pig tin moving from Pacific Coast is being consigned from Pacific Coast ports of entry to New York and after reaching New York we are asked to assist consignees in obtaining permits for shipment from New York to various points in the West, particularly in the Pittsburgh district.

"With conditions at present existing, New York terminals being practically blocked, it appears to be a burdensome method of handling on the part of the railroads, as well as being expensive to the owners of the tin.

"Effective at once we are notified by the roads reaching New York that no further shipments consigned to New York will be accepted unless permits are first obtained by consignees, so it would appear necessary to immediately adopt some method of handling and forwarding from Pacific Coast ports, including Vancouver.

"The present rate on pig tin from Pacific Coast to New York is 56.2 cents per 100 pounds. The rate in returning from New York to points in the Pittsburgh district is 15.1 cents per 100 pounds, making the extra expense for handling pig tin to New York and return to Pittsburgh district \$90.60, based on the weight of 60,000 pounds per car.

"The present rate to Pittsburgh from the Pacific Coast is 56.2 cents per 100 pounds, and from Pittsburgh to Chicago 45 cents per 100 pounds.

"Both in the interest of conserving transportation, avoiding double haul to New York and return, and also to effect a considerable saving in freight rates, recommendation is

made that further shipments of Pacific Coast pig tin be consigned either to Chicago or Pittsburgh for clearance at either one of these two points, and an additional reason making this necessary being that shipments to New York can only be made on permits to be secured by consignee in advance of shipments going forward from the coast."

It is recommended that all importers, dealers and consumers arrange, if possible, to have their shipments passed through the custom houses at the Pacific Coast port of arrival. If for any reason this cannot be done it is suggested that all shipments destined for consumption in the Middle West and the vicinity of Pittsburgh be shipped "in bond" to Chicago, Pittsburgh or other convenient interior port for distribution from such plants.

The present practice of bringing shipments for interior points through "in bond" to New York should be discouraged, as it causes congestion at New York terminals and results in great delay in the delivery of this much-needed material at consumers plants.

Moreover, the back haul from New York to Pittsburgh on a carload of 25 tons (56,000 pounds) involves an extra cost of the freight from New York to Pittsburgh of 15.1 cents per 100 pounds, equivalent to \$84.56.

The institute and the sub-committee on pig tin will co-operate to the fullest extent possible with the trade in facilitating the release of shipments at interior points.

The Princess Iron Corporation, organized under the laws of Virginia, will take over the Princess Furnace Company, the Callie Mining Company and the Circle Ore Company, all at Glen Wilton, Botetourt county, Va. Organization of the company has not yet been completed nor officers been elected.

AUSTRALIAN STEEL PRODUCTION.

The iron and steel production of Australia, comprising the operations of the Broken Hill Proprietary Company during 1917, was as follows:

	Half years ending	
	May 31, 1917	Nov. 30, 1917
	Gross tons	Gross tons
Pig iron	61,403	41,351
Steel ingots	77,676	52,878
Blooming mill	76,812	57,065
Rail mill	47,833	34,475
18-inch mill	7,767	7,461

The Ohio Electric & Controller Company, 5900 Maurice avenue, Cleveland, O., has been incorporated with a capital stock of \$200,000 for the purpose of manufacturing lifting magnets and electrical controlling devices. Lifting magnets will be built at once and controlling devices later. The officers of the new company include F. W. Jessop, president; W. B. Greene, vice president; and A. D. Walter, secretary and treasurer. Mr. Jessop was formerly works manager of the Electric Controller & Manufacturing Company, Cleveland, O. He has had an extensive experience in the manufacture of lifting magnets and electrical apparatus for the control of motors.

"Iron Ore Occurrences in Canada" is the title of a publication in two volumes sent out by the mines branch of the Canadian Department of Mines. It has been compiled by E. Lindeman and L. L. Bolton, with an introduction by A. H. A. Robinson. Volume II is devoted to descriptions of iron ore occurrences, accompanied by a copious series of maps in color.

Some Pointers on By-Product Coke Oven Operations

BY-PRODUCT COKE OVEN AND ITS PRODUCTS.

By WILLIAM HUTTON BLAUVELT.

In the earlier types of ovens, when luminous gas was used, much of the heating was done by radiation, but in modern practice, where the benzol is removed from the gas, the combustion is not luminous and the heating is done mainly by conduction. To this end, in the system described it has been found quite advantageous to maintain a reasonably high velocity of the hot gases in the flues, making use of the principle which has been developed in some types of hot-blast furnaces stoves and other furnaces, where a high velocity of the hot gases has been shown to be most effective in the transfer of heat to the adjacent surfaces because it sweeps away the sluggish layers of gas lying against the surfaces, which, if not removed, would form efficient non-conductors of the heat which we desire to transmit.

The total amount of heat delivered to the combustion flues is usually regulated by the pressure on the supply of air and gas; and the distribution of the heat among the various flues is controlled by a simple regulation of the relative amount of gas to each flue. Each flue may be conveniently inspected through a peephole accessible from the working platform outside; and it is found that the convenience of this inspection and control is an important factor in obtaining the best heating conditions.

Operation of By-Product Oven.

The coal is charged into the oven from a hoppers larry car running on the top of the oven structure, the fuel usually being delivered through four charging holes. The fifth hole serves to carry off the volatile products of the distillation. The coal is leveled after charging by an auxiliary ram on the coke pusher, the space being left between the top of the coal and the top of the oven for the outgoing gases to reach the point of discharge.

Upon completion of the coking process the doors are raised, and the coke is pushed out by an electrically operated ram. The doors are then lowered and sealed and the oven is ready for another charge. Many attempts have been made to develop a mechanically sealed door, but the conditions of operation make this mechanical sealing a difficult problem, and nearly all plants still use the mud joint. Careful designing of the door and its seat make this mudding a much less serious matter than might be supposed.

Use of Silica Brick.

As stated above, silica brick is largely used in modern by-product oven construction. There seemed at first many obstacles to its successful use for such construction, the principal objections being the large amount of expansion of the brick when heated and the tendency to spall, due to sudden changes in temperature. When silica brick was first used in the crowns of beehive ovens it was thought that it would be an absolute failure, but it was unexpectedly successful. It was first employed in by-product ovens at the plant of the Cambria Steel Company and was soon after generally adopted.

It has been found that, since most of the expansion takes place below a red heat, the variations in temperature during operations do not give any trouble, and the superior resist-

ance of silica brick to high temperatures and its satisfactory conductivity under operating heats make it a superior material. Notwithstanding its success in American practice, I understand it has not been employed to any extent in Europe, and only a few years ago some prominent English brick makers stated that they did not believe it could be employed, notwithstanding statements that came from America.

Size and Width of Ovens.

The cubic capacity of a by-product oven has increased nearly fourfold since its introduction into this country. The larger capacity has the advantage of reducing the cost of operation per unit of product, and the smaller number of units also reduces cost of construction and repairs. Increases in length and height of the oven chamber have no effect on the product and are limited only by structural and heating conditions. The width of the oven, however, is a more important factor.

In the early days of the by-product oven in Europe it was thought that the lean coals of Belgium, running as low as 15 per cent volatile, required a very narrow oven, perhaps not over 14 inches (35.5cm) wide, while for high-volatile coals a width of 20 inches (50.8 cm) was not infrequent. American practice has not demonstrated any such simple rule as this, and perhaps the reason may be found partly in the fact that oven plants are generally located at the point of consumption of the coke. Hence mixtures of coals can be more easily obtained, and for this reason most plants operate on about the same average percentage of volatile matter. It has not been definitely shown in American practice that a particular width of oven is best suited to coal of a certain composition. Narrower ovens have certain advantages.

First, a faster coking time per inch of width with a given flue temperature.

Second, a somewhat higher yield of by-products.

Third, a somewhat more uniform cell structure as between the portion of the coke nearest the wall and that nearest the center of the oven.

On the other hand, the larger number of operations of the oven crew when handling the narrow ovens increase the labor cost and the repairs. It has yet to be developed what is the best oven width to average these conditions. The widest ovens operating in this country have an average width of 21 inches (53.3 cm) and the narrowest 15 inches (38.1cm).

It will probably take much further investigation to determine where between these limits can be obtained the best equalizing of conditions, and whether the mixture of coals naturally available for a given plant will be a factor in determining the best average width. Some coals require higher temperatures than others to produce the best coke, but it is not clear that this fact will lead to the selection of wider ovens for such coals. It is not clear that we can say today that any width is definitely the best for a given set of conditions, but much study is being given to this subject, and we may before long have some better data.

I shall not go into the chemical composition of coke, since the permissible amount of any impurity for a given use is well understood, and the different elements are easily determinable. The physical structure of the coke is quite as important as its chemical composition.

Second installment of paper read by the author before the A. I. M. E. meeting, New York, February, 1918.

INDUSTRIAL SAFETY

THE PROGRESS AND POSSIBILITIES OF ACCIDENT PREVENTION WORK

BY MARCUS A. DOW.

In respect to the employer, there have been some few who have not acquired great success because, even though they pretended to inaugurate accident prevention work in their plants, they were not good safety men at heart. Successful safety work is not based on pretense. There have been those who believed that all that was necessary for them to do was to post a few safety bulletins in their plants and let it go at that. The spirit of safety did not pervade their establishments because they were not good leaders and did not make their employees feel that they were sincere. Experience has proven that success in safety springs from a service of the heart, and an ability and determination to concentrate every energy, every resource necessary, upon the obtaining of results. It has proven that success in accident prevention, just like success in anything else, will come to those who compel it—that they will achieve success who believe they can achieve it and who will put their whole hearts in the effort to attain that end. You will find that the spirit and the attitude of any employer—of any railroad official—will be reflected in every corner of his plant and on every mile of his road. You will find that if he is a safety man at heart accidents are reduced—that the majority of his employees are cooperating with him to that end—and yet his plant is working on the highest plane of productive efficiency.

There has, perhaps, been no greater benefit derived from accident prevention work than through the getting together of employer and employee in intimate conferences in regard to a matter of common interest and concern. Through the development of the employee's safety committee, employer and workmen have come to know each other, to sit around the same table, to rub elbows, to discuss a common problem, and, in the end, to understand one another's point of view. This attitude of personal relationship between employer and employee can have but one result—that of developing a harmonious feeling, and who is there who will gainsay that harmony is one of the most valuable assets of a business undertaking? It was the president of a large paper mills company who not long ago declared, "I would consider every dollar we have put into this safety work well spent even if it had not saved a life or prevented an accident, because of the get-together feeling the movement has engendered in the plant."

Let me say here that two outside factors had much to do with spurring the employer forward in the promotion of life and health conservation. One of these factors was the compensation laws in various states, which made the employer realize that the only remaining method of saving casualty expense was by preventing the accidents. The other factor was the casualty insurance companies which early recognized the many advantages of accident prevention. An emphatic proof of the value of safety work is the fact that casualty companies have offered substantial reductions in the cost of insurance based on the extent and effectiveness of safety standards. It is recorded that reductions as high as 40 per cent have been offered employers on insurance premiums by this method.

After interesting the employer, the process of interesting the employee has been quite similarly along the lines of education. The attractive safety bulletin board, containing photographs, diagrams, cartoons and tersely worded phrases of admonition and warning, pointing out vividly and impressively the known prac-

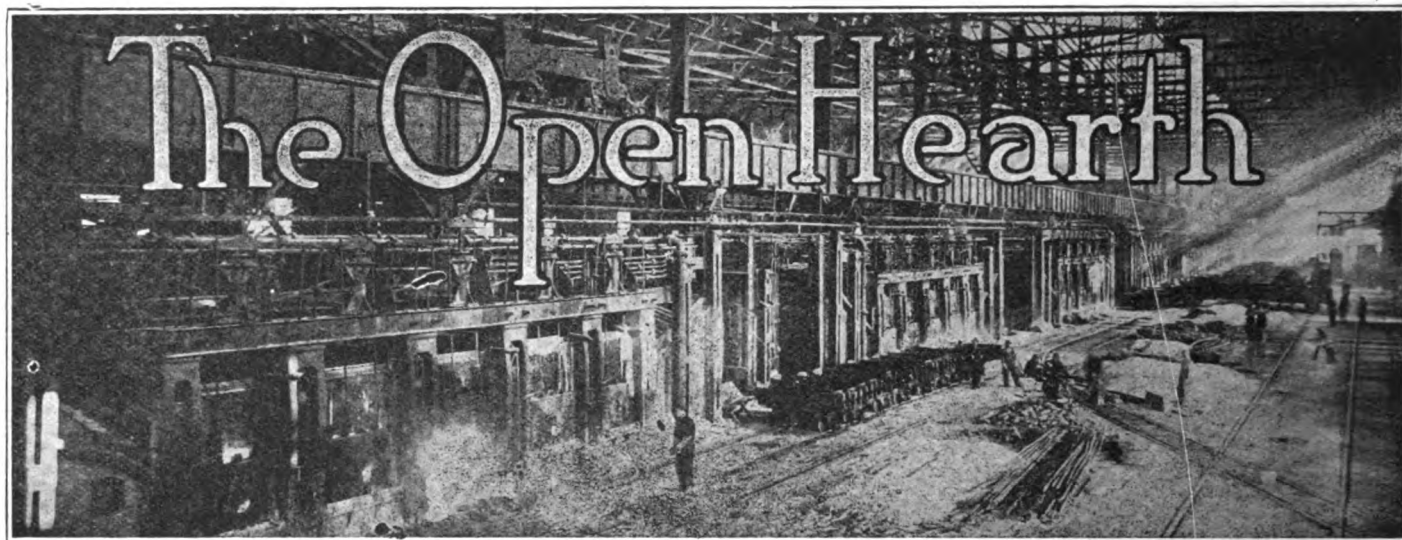
tices that cause injury, has become an important part of the equipment of shops and railroad yards. Safety rallies for employees and their families, where the doctrine of safety is preached, have become a permanent institution. Stereopticon views, showing the unsafe and safer methods of performing work, and motion pictures telling a forceful heart interest story and driving home the unhappy consequences of carelessness, have played a most important part in awakening and educating the rank and file of employees.

The education of the foreman or the man charged with supervision, is now conceded to be of first importance if safety work is to be effective. Eternal vigilance is regarded as the price of safety, and we have come to realize that the vigilance of the man in charge must extend so far as to see that the men under him are closely supervised as to the elimination of unsafe practices, and that they are taught to do their work with such care and caution as will preclude the possibility of injury. Thus the foreman becomes a most important factor on the human element side of the accident prevention problem.

But of all these important developments, perhaps there is none so potent, none so significant of progress, as the one which has brought forth the safety engineer—the future guardian of the human race. He is the spearpoint of the safety movement. It is his initiative, his ingenuity his expert knowledge gained from ceaseless study, and his inspiration derived from a full realization of the possibilities of his work that serves to prod others into action, stimulate interest and promote the co-operative spirit in accident prevention among employers and employees alike. Operating officials, with their manifold duties, cannot keep continually developing new ideas in accident prevention. Thus the safety engineer has become almost indispensable to the successful conduct of this work. Experience has shown his territory should be confined to an area which will permit him to come into frequent personal contact with a majority of the employees under his jurisdiction. Let me cite the experience of the railroad which I represent. The New York Central Lines originally employed in their safety bureau several safety agents who covered a wide territory where close supervision and frequent contact with the men was impossible. A year ago we tried as an experiment the employment of a few division safety agents on certain main line divisions. After several months' trial it was found that the accident records on these divisions, compared with the same months the previous year, was from 20 to 35 per cent lower than it was on similar divisions where there were no division safety agents. Therefore, commencing July 1, 1916, the New York Central Lines took a new step in safety progress by appointing division safety agents on all of the main-line divisions of the system.

But what, you will ask, has been accomplished in all of this development of the safety idea in the way of actually reducing the number of accidents? After all, "It is by their deeds that ye shall know them." The record of accomplishment in saving lives in hundreds of industries and on the railroads forms one of the brightest pages in the history of American industry. There is perhaps a no more striking example of what consistent safety work will accomplish than the record that has been made by the railroads of the United States in the past few years—a record that has been made in spite of increased traffic, labor disturbances, and numerous other operating conditions. On all the railroads of the country, during the seven years ended June 30, 1916, there has been a steady decrease in the number of railroad employees killed and injured while on duty.

Second installment of paper read by the author before the Sixth Annual Congress of the National Safety Council.



Col. Henry P. Bope has resigned his position as vice president and general manager of sales with Carnegie Steel Company to devote his time to private interests.

Col. Bope was born and educated at Lancaster, O., and devoted himself at first to stenographic reporting in the Ohio legislature. In November, 1879, he became connected with Carnegie Brothers & Co. and has remained continuously in the sales work of that company and its successors up to the present time. His period of service has thus covered the wide expansion of the use of steel and the growth of great commercial and business organizations, in all of which he has had a most active part. In addition to these commercial activities he has been active in the social life of the community.



COL. HENRY P. BOPE.

He has been succeeded in his office with the Carnegie Steel Company by William G. Clyde. Mr. Clyde was educated in the Pennsylvania Military College, at Chester, Pa. He first entered the employ of Ryan & McDonald, contractors, of Baltimore, Md., was then associated with Robert Wetherill & Company, machinists and founders, and was later superintendent of the plate mills of the Wellman Steel & Iron Company, in Thurlow, Pa. His connection with the United States Steel Corporation and its subsidiaries dates from 1894, when he became superintendent of the plate mills of the Illinois Steel Company, at South Chicago.



WILLIAM G. CLYDE.

On the formation of the American Steel Hoop Company he became traveling salesman for that company in Chicago, and five months later was made manager of sales at Philadelphia, where he remained until 1902, when, after the formation of the United States Steel Corporation, the American Steel Hoop Com-

pany was merged with Carnegie Steel Company. For the next three years Mr. Clyde was traveling salesman for Carnegie Steel Company, at Cleveland. In September, 1905, he was made assistant general manager of sales at Pittsburgh, in charge of the bureau of bars and hoops, which office he retained until his present promotion. Mr. Clyde by the promotion has also become a member of the board of directors of the company.

While Mr. Clyde belongs to the younger generation of steel makers, his experience in the actual manufacture of steel, his wide experience in sales work, grasp of details, indefatigable energy and strength of character indicate that he will be a potent factor in the commercial activities of Carnegie Steel Company and the steel industry.



CHARLES L. WOOD.

Charles L. Wood, long assistant to Mr. Clyde, has been promoted to be assistant general manager of sales in charge of the bureau of bars and hoops. Mr. Wood was born in Youngstown, O., in the atmosphere of iron and steel manufacture. He was educated as a mining engineer at the Ohio State University and his first employment was with the Calumet Furnace Company, of Chicago, Ill., as chemist, followed by several years' experience in the practice of mining engineering in Colorado and the West.

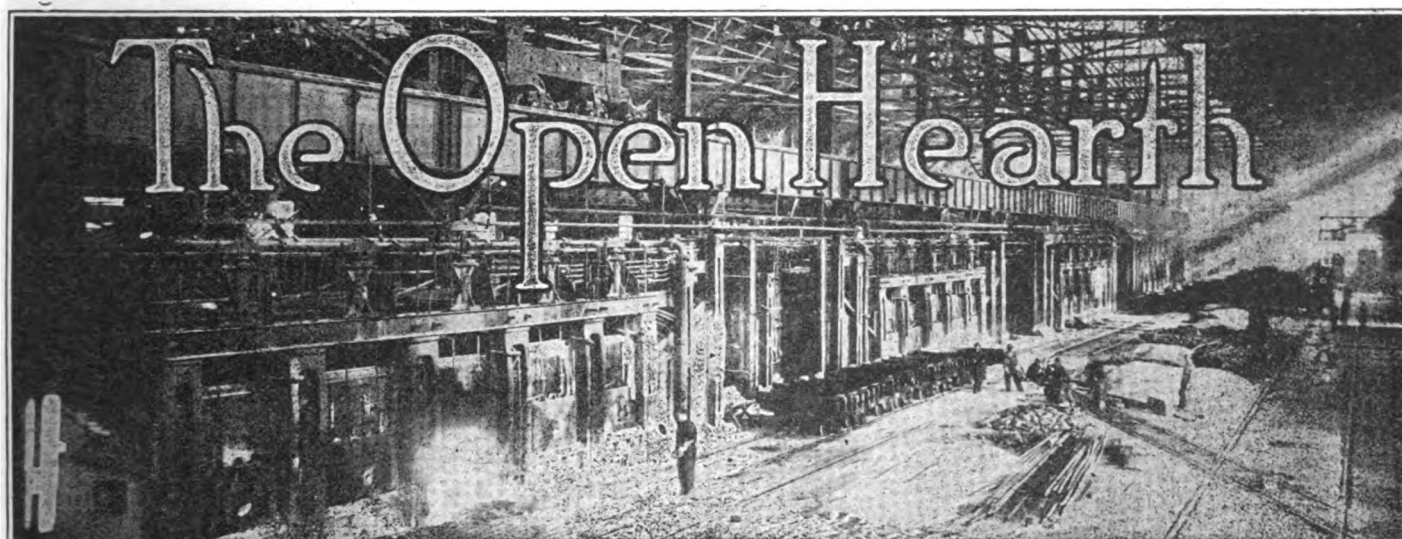
Mr. Wood became associated with the American Steel Hoop Company on its formation, first in the order department. On the merger of the hoop company with Carnegie Steel Company his ability caused his transfer to the sales department where, in the bureau of bars and hoops, he has long been Mr. Clyde's most efficient assistant. His promotion, therefore, comes as a logical recognition of his large experience in the sale of bar mill products and his wide acquaintance with their users.

V V

C. P. Kimmel has been appointed assistant superintendent in charge of the rolling mills at the Gary works of the Illinois Steel Company.

V V

Quincy Bent, formerly general manager of the Steelton plant of the Bethlehem Steel Company, is now vice president and is located at South Bethlehem, Pa.



The following have been elected to membership in the American Iron and Steel Institute:

Archer M. Campbell, Glamorgan Pipe & Foundry Company, Lynchburg, Va.; Francis H. Hardy, South Eastern Iron Corporation, Chicago, Ill.; John J. Howard, Lavino Furnace Company, Lebanon, Pa.; William H. Hulick, Warren Foundry & Machine Company, New York City; E. George Lavino, E. J. Lavino Company, Philadelphia, Pa.; William J. McCurdy, Manufacturers Iron & Steel Company, Catasauqua, Pa.; Theodore E. Moritz, American Steel Foundries, Chicago, Ill.; W. W. Pettis, Cincinnati, O.; George W. Nancy, Atlantic Steel Company, Atlanta, Ga.; Charles J. Stark, The Iron Trade Review, Cleveland, O.; James H. Walsh, Illinois Steel Company, South Chicago, Ill.; Charles H. Williams, American Iron Products Company, Inc., New York City; H. H. Broderick, Muncie, Ind.; George Frank Konold, Warren Tool & Forge Company, Warren, O.; William Sigler Jones, Vanadium-Alloys Steel Company, Latrobe, Pa.; George Coffin Warren, Fulton Steel Company, New York City.

V V

Louis H. John, formerly in the engineering department of Canadian Steel Corporation, at Ojibway, Ont., Can., is now in the mechanical engineering department of Cambria Steel Company, Johnstown, Pa., as a draftsman.

V V

W. F. Roberts is now general manager of Maryland plant of the Bethlehem Steel Company, at Sparrows Point, Md.

V V

H. C. Thomas, assistant superintendent of the Gary works, Illinois Steel Company, who has been connected with this firm for over 10 years, first as chemist and metallurgist and later as assistant superintendent, has resigned.

V V

D. B. Clark is now general superintendent of the Watervliet Arsenal, Watervliet, N. Y. He was formerly superintendent of the shell department of the American Brake Shoe & Foundry Company, Erie, Pa.

V V

W. J. Gilmore, formerly superintendent of the plant of the American Steel Foundries at Indiana Harbor, is now works manager of the Hubbard Steel Foundry Company, East Chicago, Ind.

V V

Frank E. Norris, superintendent of the Carnegie Steel Company's plants at Sharon and Farrel, Pa., has resigned. He has taken a three-year contract with Berliet, an automobile manufacturer of France. Mr. Norris will be engaged in building a large steel plant in France.

H. G. Weidenthal has joined the staff of James H. Herron, Cleveland, O., engaged in metallurgical, chemical, testing and inspecting engineering work. Mr. Weidenthal was formerly works manager of the General Steel Company, Milwaukee.

V V

E. L. Haug is now vice president and treasurer of the United Alloy Steel Corporation, Canton, O. He was formerly secretary-treasurer. J. P. Mosely, formerly assistant secretary, is now secretary.

V V

F. G. Gasche, mechanical engineer at the South works of the Illinois Steel Company, Chicago, is opening an office in Chicago at 10 South La Salle street, where he will be engaged in general consulting engineering work.



Mr. Gasche started to work for the Illinois Steel Company some 28 years ago, as steam engineer at Union works. During the year 1892 he was transferred to the South works in the same capacity, and in 1895 he was given charge of the steam engineering work for all the Illinois Steel Company's plants. For a period of 10 years thereafter he was actively engaged in supervising the testing and assisting in the design of improvements for the power plants of the company.

Mr. Gasche served for several years as chairman of the Steel Corporation committee of steam engineers.

V V

George L. Danforth, Jr., formerly superintendent of steel construction, has been appointed assistant general superintendent of the South works of the Illinois Steel Company, succeeding Herman A. Brassert.

V V

H. B. May, efficiency engineer of the Youngstown Sheet & Tube Company, has enlisted in the aviation corps.

V V

C. F. Danielson, formerly works manager of the Youngstown Pressed Steel Company, a subsidiary of the Youngstown Iron & Steel Company, has retired to become engaged in government work.

V V

A. L. Cromlish, blast furnace superintendent of the Carnegie Steel Company's furnaces at Farrel, Pa., has been elected a director of the Colonial Trust Company.

V V

T. E. Agnew is now assistant superintendent of blast furnaces of the McKinney Steel Company, Cleveland, O.

WITH THE EQUIPMENT MANUFACTURERS

ELECTRIC FURNACES GO TO HIGHER CAPACITIES.

With the advent during the past year of 20-ton electric furnaces and indications of an advance to a standard maximum of 30 tons, the General Electric Company has developed an improved system of automatic control to handle the motive power necessitated.

These improvements became necessary as the rate of steel

ically interlocked, two contactors being normally open and one being normally closed.

Facing the panel, the left-hand contactor of any group makes the necessary connections to raise the electrode, while

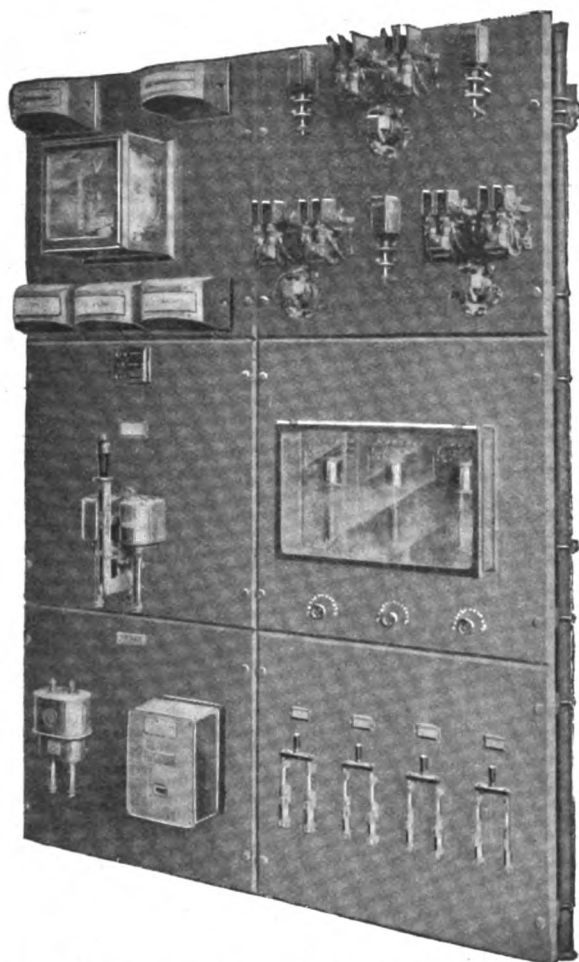


Fig. 1—Hand automatic control switchboard for electric furnace.

production in these furnaces had been increased by the use of higher capacity transformers and higher voltages, which permitted forcing power into the furnaces at considerably higher rates.

The control panel is made in three sections, as shown in Fig. 1. The top section contains three shunt relays and three contactor groups; the total number of each being in accordance with the number of electrodes used. The middle section has three contact-making ammeters, each provided with dash-pots to prevent hunting, and with coils provided with taps which are used to vary the amount of power supplied to the furnace. Beneath are three small dial switches which are connected to the coil taps. On the lowest section there are four d.p.s.t. knife-blade switches with fuses, one switch being used for the line and the others for the electrode motors.

Each contactor group consists of three units, all mechan-

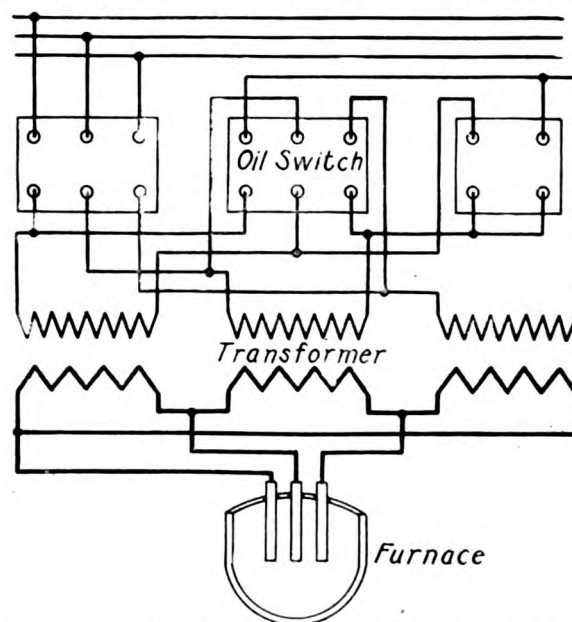


Fig. 2—Connection diagram of three-phase furnace arranged for variable voltage operation by means of changing high-voltage connections—The high-melting voltage is obtained by connecting high-voltage winding delta and low-refining voltage by connecting them "Y."

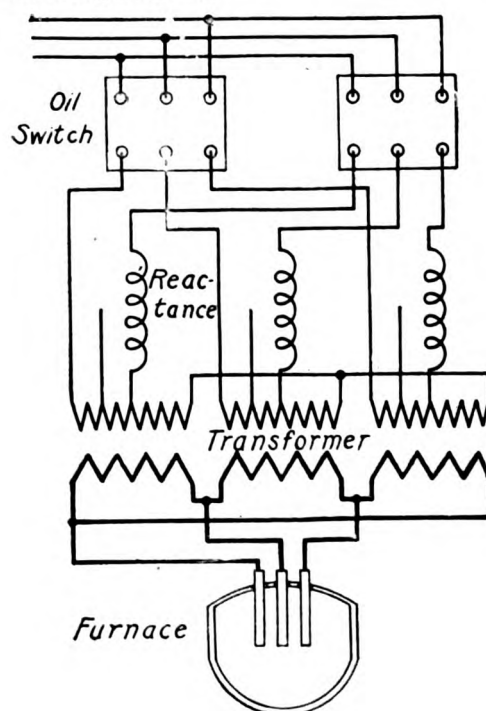


Fig. 3—Connection diagram of furnace equipment—Variable voltage is obtained by means of high-voltage taps and external reactance is provided to be cut in during the melting period.

WITH THE EQUIPMENT MANUFACTURERS

the right-hand contactor causes the electrode to be lowered and the bottom contactor short-circuits the motor armature through a resistance, in this way dynamically braking all moving parts and stopping them almost instantly. A higher resistance is connected in circuit with the armature when lowering than when raising, this being done to keep the speed approximately constant.

The shunt-wound electrode motor is connected to the line until the desired regulation is obtained, when the motor is disconnected and stopped almost instantaneously by means of dynamic braking, this method giving the simplest and most positive control of the electrode movement. The type of motor used was designed for this particular service, especially in regard to self-lubricating bearings, and ranges in size from 1 to 1½ hp for small equipments, to 5 hp for 15 to 20-ton furnaces.

The higher power used can be seen by taking for example, the 6-ton furnace, which is the size in greatest general use. The transformer capacity has increased from 900 kva to 1,500 kva, and even 1,800 kva has been proposed; all these capacities being based on 100 volts. In the variable voltage equipments the successful use of 150 volts renders it possible to increase the normal 1,500 kva up to 2,250 kva.

Although 100 volts remains standard for refining, voltages up to 173 have been used for melting; these voltages being obtained either by high voltage taps or high voltage Y data. When it is considered desirable to use external reactance with high voltage taps, the method of using these reactances is shown in illustration.

The use of high voltages during melting down permits of decreasing the current for a given input, improves the power factor and insures higher emergency input when most needed.

FURNACE SHIPPED TO INDIA.

The Industrial Electric Furnace Company, of Chicago, Ill., makers of the Snyder furnace, have shipped a 1,250-pound capacity electric steel furnace, together with the auxiliary electrical equipment, to Burn & Co., Calcutta, India. Burn & Co. are the largest and most progressive iron, steel and foundry company in India. The purchase of this Snyder furnace shows the progressive tendency toward modern equipment and modern practice in that field. The purchase was made by A. Anderson, representative in America for Burn & Co., through the Northwest Trading Company, of Seattle, Wash, after a thorough investigation of all types of electric furnaces.

NEW CAPACITIES ATTAINED BY ELECTRIC CRANES.

As a result of the speeding up of shipyards and industrial plants in 1917, there was a greatly increased demand for cranes, electrically operated and controlled.

Six of the largest of these cranes were equipped with motors made by the General Electric Company and in most cases with G-E control.

Two cranes were of 225-tons capacity, the total motor rating of each aggregating 420 hp.

A third crane of the same capacity had motors with a total intermittent rating of 850 hp. The two main hoist motors each had a rating of 250 hp for continuous, and 425 hp for intermittent service, giving a hoisting speed for 225 tons of 40 feet per minute, and 120 feet per minute for 60 tons. Due to the high and variable speeds required, the large cur-

rent demands could not be handled to the best advantage through the usual arrangements of rheostats and contactors, and Ward-Leonard control was, therefore, provided; this being the first application of this system of control on large cranes.

The remaining three cranes were the largest capacity units of this type ever built, being designed for a full-load lift with the main hoist hook of 330 tons at 126 feet per minute. The power equipment for each crane comprised two 200-hp main hoist motors, two 105-hp auxiliary hoist motors, and 80-hp and 30-hp motors for main and auxiliary trolley, and two 50-hp motors for bridge motion; all these capacities being intermittent ratings.

Two high-speed alternating-current hammer-head coal-handling gantry cranes, provided with a unique system of dynamic braking, were installed at the La Belle Iron Works plant, at Steubenville, O. Each crane is equipped with a 375-hp slip-ring induction motor direct coupled to a 40-hp direct-current motor, and hoists a four-ton bucket of coal at 500 feet per minute. The dynamic braking is obtained by combining the small direct-current motor with the alternating-current motor, so that the direct-current unit serves as an exciter and gives dynamic braking, which is comparable with that ordinarily obtained with direct-current motors on this class of work. This is the first application on any large scale of this system of dynamic braking for cranes, which is more economical in first cost and has a number of practical operating advantages when compared with the method which utilizes a motor-generator set in addition to an exciter for securing dynamic braking for alternating-current hoist motors. Creeping speeds of 110 feet per minute, lowering, are obtainable with these cranes under ordinary service conditions.

BOOTH-HALL ELECTRIC FURNACE INSTALLATIONS.

Contracts have recently been placed with the Booth-Hall Company, 565 West Washington boulevard, Chicago, Ill., for the following units:

A one-ton furnace for the Queen City Foundry Company, Denver, Colo., which is at present operating a converter steel foundry; a two-ton furnace for the Monroe Steel Casting Company, Monroe, Mich., which is at present operating a single-phase electric furnace which will be replaced by the new unit; a two-ton furnace for the New England Steel Casting Company, a new steel foundry which will be located at Springfield, Mass.; a two-ton furnace for the Four Wheel Drive Auto Company, Cantonville, Wis., which is installing a new steel foundry to produce castings for trucks for the United States government. The output of this company has been hampered by inability to secure sufficient quantities of steel castings; a two-ton Booth-Hall furnace has recently been put into operation in the new steel foundry of the Avery Company, Peoria, Ill., for producing gears, pinions, and other agricultural machinery and tractor castings. A one-ton unit is ready to be put into operation at the plant of the Duriron Casting Company, Dayton, O. With the five-ton unit which has been in operation at the Midland Electric Steel Company, Terre Haute, Ind., this makes three sizes of furnaces that the Booth-Hall Company has designed and put in operation since last June when the company was formed.

Trade Publications

Safety Switch—Safety auto-lock switches are described and illustrated in some detail in special publication No. 1585-A just issued by the Krantz Manufacturing Company, Inc., of Brooklyn, N. Y. These switches are designed for use on circuits wherever the ordinary knife switch may be applied. They are especially designed for safety, it being absolutely impossible to touch the live parts regardless of the position of the switch or of the door. They are particularly adapted for use in steel mills, factories, mines, and other similar locations where men are employed who have no practical knowledge of electricity.

Centrifugal Pumps—The Wheeler Condenser & Engineering Company, of Carteret, N. J., has just published bulletin No. 108-B, embracing exclusively their line of centrifugal pumps. The bulletin shows the latest Wheeler turbine-driven geared centrifugal pumps; bi-rotor; tri-rotor; electric driven; small belt driven; small high speed; side, end and bottom suction; vertical shaft; pumps for either series or parallel operation; and special slow-speed engine-driven pumps. Test curves made by both manufacturer and customer are included in the bulletin, giving the characteristics of Wheeler high grade design. Wheeler pumps are made for all services and especially for installations where large volumes of water must be pumped economically against low heads.

Clam Shell Buckets—The Blaw-Knox Company, Pittsburgh, Pa., has issued an interesting booklet descriptive of their single line clam shell buckets. The bucket is a one-man, and can be dumped by the rig operator by means of a tripping lever, or by simply lowering the closed bucket until it touches the ground, where it trips automatically.

Oxygen and Hydrogen Generator—The Electrolytic Oxy-Hydrogen Laboratories, 15 Williams street, New York, has published a bulletin illustrating and describing the Levin oxygen and hydrogen generator. The generator consists of three compartments. The oxygen is generated in the two outer compartments and the hydrogen in the center compartment. Two sheet metal frames, to each of which is attached an asbestos diaphragm, serve as the separating mediums. The electrodes are independent of the casing. They are separated from and securely fixed within the casing by specially designed blocks of asbestos. The surfaces of both the anode and cathode are plated. The use of cobalt for such purpose is one of the unique features of the Levin generator. Each compartment has an independent water feed which also serves the purpose of a blow-off device to vent the gas from each compartment under abnormal conditions.

Government Publications—Technical Paper 141—"Laboratory Determination of the Inflammability of Coal Dust and

Air Mixtures," by J. K. Clement and C. N. Lawrence. 1917. 35 pp., 1 pl., 15 figs. Technical Paper 162—"Initial Priming Substances for High Explosives," by G. B. Taylor and W. C. Cope. 1917. 32 pp. Technical Paper 181—"Determination of Unsaturated Hydrocarbons in Gasoline," by E. W. Dean and H. H. Hill. 1917. 25 pp.

Applications for these publications should be addressed to the Director of the Bureau of Mines, Washington, D. C.

Copper Castings—The Titanium Bronze Company, Niagara Falls, N. Y., has issued a pamphlet relative to high conductivity copper castings, showing the importance of hardness; the maximum hardness and electrical conductivity obtained by titanium methods and special processes of producing density in massive castings.

Graphic Records—The monthly bulletin of the Esterline Company, Indianapolis, Ind., contains interesting information concerning the use of graphic instruments. A prize is offered to anyone submitting articles describing experiences with the Esterline graphic meter.

Pendant Switches—The Cutler-Hammer Manufacturing Company, of Milwaukee, Wis., has recently issued a small two-color envelope folder, publication No. 242, illustrating and describing both single and two-circuit brass shell and all porcelain pendant switches. The approved C-H high capacity quick-break mechanism is used in this line, the operating push-buttons of which are a part of the mechanism and do not loosen up, twist or become lost.

Hydraulic Valves—A new catalog of hydraulic valves and fittings has just been issued by the Hydraulic Press Manufacturing Company, of Mount Gilead, O. The book is quite elaborate in make-up and presents the complete H-P-M line very attractively. The four general classes of hydraulic valves are clearly illustrated and described. These are operating, check, knockout and safety. Every standard type of hydraulic fitting is also listed, also accumulator controls, pressure gages, hydraulic pipes, etc. Many of these hydraulic devices are of improved design and are here published for the first time. Interested parties may obtain copies from the above address.

Trade Notes

The Asbestos Protected Metal Company, of Pittsburgh, Pa., announces the appointment of Herbert Longstaff as manager of its St. Louis office, located in the Boatman's Bank Building.

The Westinghouse Electric & Manufacturing Company announces the removal of its office from Phoenix, Ariz., to Tucson, Ariz. Its representatives, Messrs. J. H. Knost and W. G. Willson, will have headquarters in the Immigration Building at the latter point.

The Westinghouse Electric & Manufacturing Company, of East Pittsburgh, Pa., has recently secured the exclusive

sales agency for the United States for Frankel solderless connectors, widely used for joining electrical wires and cables. Manufacturing facilities have been increased by the Frankel Connector Company, in order to care for the new business to be secured through the Westinghouse sales organization. The Westinghouse company will act also as a distributor of Frankel testing clips.

W. H. Thompson, for many years prominent in the heavy electric traction work of the Westinghouse Electric & Manufacturing Company, has resigned to accept the position of works manager of the Fairmont Mining Machinery Company, of Fairmont, W. Va., makers of coal mining equipment.

To obtain even greater benefit from a widely established reputation for efficient power-plant accessories, the Yarnall-Waring Company has decided to group their several products under the family name of "Yarway."

Fred B. Crosby has resigned his position in the power and mining engineering department of General Electric Company, Schenectady, N. Y., to become the electrical engineer of Morgan Construction Company, Worcester, Mass. Mr. Crosby has specialized in electrical equipment for steel works.

In order to take care of the increased demand for Smith clean gas producers, the Smith Gas Engineering Company have about completed their new plant at Moraine, O., near Dayton. The main building of this plant is 110 x 410 feet long and is being equipped with modern tools throughout. The main office of the company is now located at Dayton, O. The plant at Lexington will be kept in operation.

Obituary

Thomas Walker, treasurer and director of the Columbia Steel & Shifting Company, died at his home in Pittsburgh, Pa., April 9. Mr. Walker was also president of the Merchants Savings & Trust Company, Pittsburgh, Pa.

Austin Clement, president of the Page Steel & Wire Company, died in Chicago, Ill., March 30, after a long illness.

Society Meetings

American Iron and Steel Institute's fourteenth general meeting at the Waldorf Astoria, New York, Friday and Saturday, May 24-25, 1918.

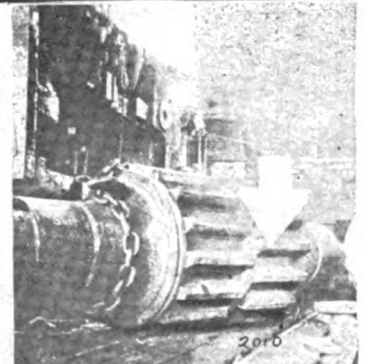
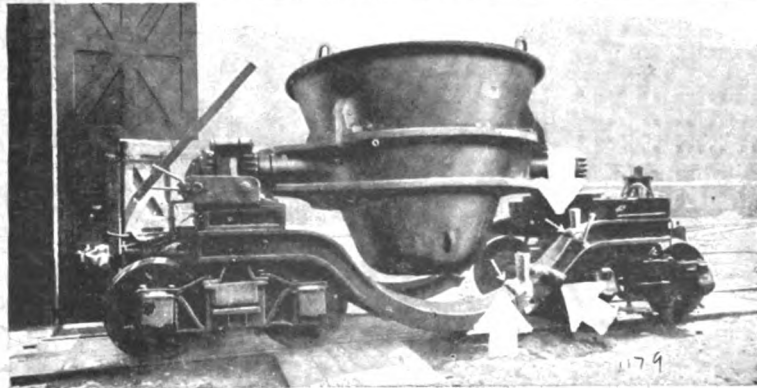
A. I. S. E. E. joint technical session of Pittsburgh and Cleveland district sections Saturday, May 18, at Youngstown, O. Inspections of McDonald and Ohio works, Carnegie Steel Company.

Philadelphia section meeting of A. I. S. E. E. on May 4. Paper to be read by P. B. Liebermann on "The Application of Roller Bearings to Cranes."

The annual convention of the A. I. S. E. E. will be held at the Southern Hotel, Baltimore, Md., September 9-14, 1918.

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Pittsburgh, May, 1918



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